DEC 9 1941

For Editorial Contents see page 451

PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

TEMPORARY OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 18 & 20, COMPTON ROAD, HAYES, MIDDLESEX.

VOL. 152—No. 3960. LONDON: FRIDAY, DECEMBER 5, 1941. Registered at the General Post Office as a Newspaper PRICE 1s. BY FOREIGN POST 1s. 2½d.

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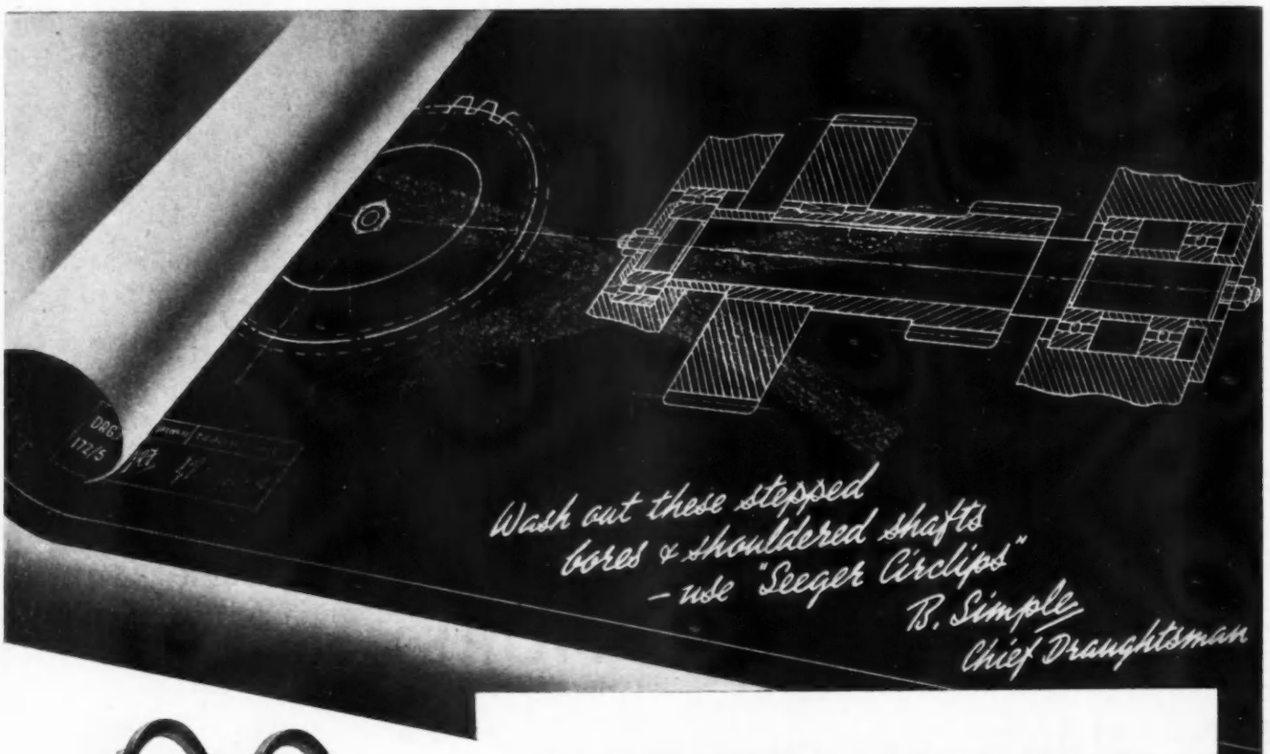

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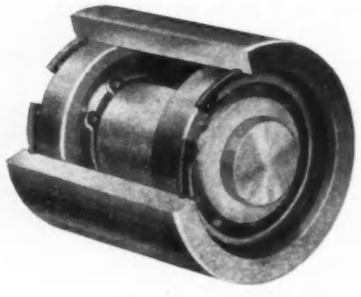

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THE CLAYTOR HYDRO-ELECTRIC POWER PLANT.

(*Concluded from page* 422.)

THE three Francis-type water turbines installed in the power house are supplied through 16-ft. internal diameter steel penstocks; these are of riveted construction throughout. Where they enter the power house they are served with two coats of granulated cork on the outside to absorb condensed moisture. The intakes are each provided with two head-gates, as shown in Fig. 4, on page 423, *ante*. One is a weighted flat gate and the other a Broome gate. They are electrically operated, the arrangements being such that the Broome gate must be fully open before the flat gate can be raised, and the flat gate fully closed before the Broome gate can be lowered. Control can be effected both from the main switchboard and from the hoist housings on top of the dam, the push-button switchboard control being intended only for emergency operation. Stop-log closing is also provided on the upstream side of the gates, the arrangement being similar to that already described in connection with the spillway gates; it is shown in Fig. 4.

FIG. 8. INTERIOR OF POWER HOUSE.

Each turbine is rated at 26,000 h.p., when operating under a head of 110 ft. and running at 138·5 r.p.m. The scroll cases are of riveted steel-plate construction and are embedded in the concrete sub-structure, as shown in Fig. 4. A compressible layer was inserted between the top of the cases and the concrete to prevent cracking of the turbine-room floor owing to possible expansion of the scroll cases under water pressure. The guide bearings of the turbines are of the babbitted-sleeve type. To minimise leakage through the wicket gates when the units are not in operation, rubber seals are provided at the top and bottom of each gate. Each machine is controlled by a Woodward cabinet-type governor, in which the actuator, pumping unit, sump tank and restoring mechanism are housed in a compact unit. A panel carrying gauges showing the oil-pressure and gate-position is mounted at the end of each governor cabinet.

The three-phase alternators are each rated at 20,833 kVA when running at 138·5 r.p.m. They generate 60 cycle, 11,000-volt current. Each has a directly-connected 250-volt main exciter and a 250-volt pilot exciter. In order that they may be operated as synchronous condensers, each generator has an over-excited capacity of 13,200 kVA at zero power factor at rated voltage, and an under-excited capacity of 18,333 kVA at zero power factor at rated voltage. The generators, the upper portion of which can be seen in the interior view of the power house given in Fig. 8, on this page, are of umbrella-type frame construction and are fitted with self-oiling Kingsbury thrust bearings and water-cooled combined guide and thrust bearings, the latter being located immediately below the rotors. Two surface-type coolers are installed for the ventilation of each alternator. These are situated in the machine foundations and are supplied with gravity-fed cooling water from the river. In the summer the alternator ventilating air operates on a closed system, but in winter part of the air is bled off to warm the power house.

The whole output of the generators is delivered to banks of transformers situated on the roof of the power house above the 11,000-volt 'bus bars, as shown in Fig. 4, on page 423, *ante*. The photograph of the completed dam, taken from the power-house end, which is reproduced in Fig. 11, on page 443, clearly shows the arrangement of these transformers. A diagram of the main connections is given in Fig. 10, on page 442. There are two main transformer banks, each having a normal continuous capacity of 43,500 kVA, but capable of carrying 50,000 kVA; this larger load may be imposed when it is desired to take advantage of high river discharge. The banks are each made up of three 11,000-volt to 132,000-volt 14,500-kVA single-phase oil-insulated and forced air-cooled units. A seventh spare transformer is provided. This has Pyranol* insulation, with forced circulation, a separate air-cooled radiator system being provided for cooling the Pyranol; the forced circulation saves space and weight. There are also two 1,500-kVA, 11,000-volt to 460-volt house transformers. A Mulsifyre system of fire protection is provided, a number of sprinkler heads being located round each transformer. Their operation is controlled by thermostats, which actuate relays and start the fire pump. As can be seen in Fig. 11, there is a rail track in front of the transformer banks. This is used to remove individual units for inspection or repair. They are lowered through a hatch into the power house, where servicing can be carried out with the help of the 120-ton overhead crane.

An oil-handling system is installed for supplying and changing the oil in the transformers and circuit breakers. A purifier and filter-press, together with the pumps, are located in a building situated on the river bank immediately to the south of the power house. Adjacent to this, there are 7,500 gallon storage tanks for transformer and circuit-breaker oil. There are two clean-oil tanks, one containing reserve supplies for the transformers and the other similar supplies for the circuit breakers. A third tank is used for storing dirty oil of either type, when the contents of any part of the equipment is being changed. Two steel pipes, 3 in. in diameter, provide a connection from the oil house to the circuit breakers in the switching station on the hillside, which is referred to below, and by means of which the station is connected to the outgoing transmission lines.

As mentioned in the previous article, the Claytor power station delivers its whole output to the transmission lines connecting the Roanoke and Glen Lyn plants of the Appalachian Electric Power Company. These lines were installed ten years before the construction of the Claytor dam, but a route was selected which brought the lines as closely as possible to the known site of the future dam. As a result of this foresight the new plant has been connected into the lines without it being necessary to alter the position of any of the original line towers, or to install additional ones. The only new material required has been the steel framework and circuit breakers of the switching station, which is of the outdoor type. The station is situated on the south abutment of the dam 360 ft. above the elevation of the turbine-room floor. It is connected to the power house by an electric tramline mounting the slope.

As will be seen from Fig. 10, the generators are connected, through circuit breakers, to two 11,000-volt 'bus bars, which can be coupled through section switches, and a circuit breaker, to form a single bar. There are no breakers on the high-tension side of the transformers at the power station, but it will be seen from the arrangement of disconnecting switches and breakers at the switching station, which is shown in Fig. 10, that a breakdown of a transformer bank or generator, or trouble on either of the station 'bus bar sections, will still leave the other half of the plant connected to the remaining transmission circuit. The switching station is arranged for complete automatic operation. Each of the 132,000-volt line breakers is equipped with reclosing relays which allow two automatic reclosures, in case of line overload, before the line is cut out. The tie circuit breaker, connecting the two 'bus bars in the switching station, recloses only if both bars are energised and only under control of a check-synchronising device. The line breakers have ultra high-speed reclosing mechanisms which permit re-energising of the line within 18 cycles from the time that the tripping impulse is first given. Experience shows that this rapid reclosing will restore the service in 90 per cent. of the line tripping which occur without noticeable interference with operating conditions on the system.

The 11,000-volt power-house switchgear is of the metal-clad type, entirely housed in steel compartments provided with safety devices and interlocks. A general view of the circuit breaker and disconnecting switch cubicles is given in Fig. 9, on page 442. The breakers are of the small oil-content type. When this gear was being designed, consideration was given to the use of either water or air-blast breakers, but it was decided that experience with either type was not sufficiently extensive to justify its adoption for this important installation. The gear was, however, arranged so that, if desired, a change could be made in the future to either type. Experience elsewhere on the system of the American Gas and Electric Company suggests the air-blast breaker as a promising line of development. As will be seen from Fig. 10, the high-tension sides of the 440-volt house transformers are connected one to each section of the 11,000-volt 'bus bars. In the event of failure of one of these transformers, the 11,000-volt 'bus-section switch will, if necessary, be closed and the sound transformer fed from the other high-tension 'bus section. Normally, the station is operated with this section breaker open.

The whole of the gear is covered by some form of differential protection. For instance, No. 1 11,000-volt 'bus bars and No. 1 main transformer bank have differential protection from the live side of the 132,000-volt line current breakers to the 'bus bar side of the 11,000-volt circuit breakers; time-delay

* See ENGINEERING, vol. 148, page 643 (1939).

over-current relays are used. The transformers are further protected by a faster and more sensitive type of unbalanced relay. The 11,000-volt 'bus bars are also protected by a simple 'bus differential arrangement of instantaneous over-current relays. Differential relays of the percentage unbalance type are also arranged round each generator. The whole scheme ensures that trouble on any 'bus bar, transformer bank or generator will be cleared in a minimum of time and with a minimum of resulting damage, any disturbance being confined to one half of the station and the other half being unaffected. The whole of the gear, including that in the switching station, is controlled from a board in the generator room. It is equipped with the necessary relays, meters and control switches. The control connection to the switching station is made by means of a non-metallic sheath cable laid in the ground alongside the inclined railway, no mechanical protection being provided other than the earth covering. Although, as previously explained, the switching station is arranged for automatic operation, sectionalising operations may have to be performed from the control board, in response to instructions from the load dispatcher, in case, for instance, of trouble elsewhere on the system. As the distance between the power house and the switching station is considerable, a duplicate control battery has been installed in the foundations of the sectionalising circuit breaker in the switching station. This is required particularly for furnishing the closing current for the 132,000-volt breakers.

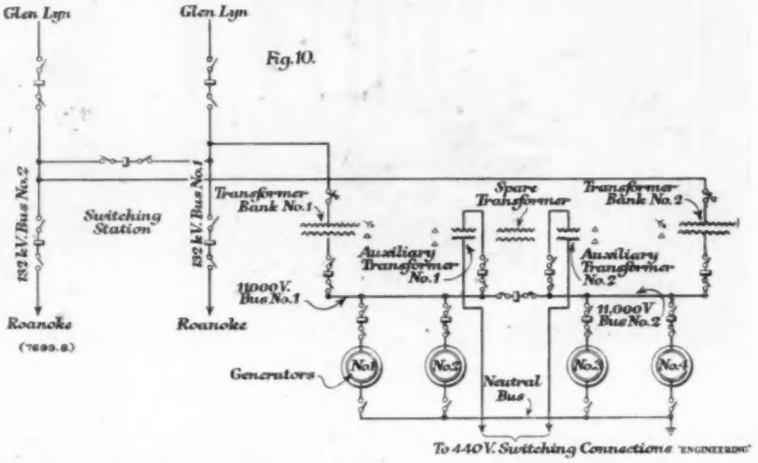
The generator units are arranged for automatic starting and stopping, the attendant having only to operate a single switch, after which the automatic equipment brings the turbine up to normal speed, synchronises the alternator and distributes the load. A very complete system of protective devices is installed. This operates in cases of under- or over-voltage and over-speed, or of undue rise of temperature in the turbine bearings, stator or field. The protective arrangements also come into action in cases of oil-pressure or bearing-oil cooling-water failure, if the machine falls out of step, or in case of field breakdown. They also control the CO_2 fire-protection equipment. These protective devices were tested in service within three months of the plant being put into commission. A severe short-circuit occurred on the low-tension side of one of the transformers and the generators were disconnected from the line on the second swing out of step. It is probable that this rapid action saved damage to the amortisseur windings with which the machines are equipped.

As it may be necessary to control the load on the Glen Lyn transmission lines, a complete system of frequency and load control has been installed at the Claytor station. This allows one, or two, of the generator units to be controlled so that the system frequency will be held at a predetermined value regardless of changes in the load on the transmission lines or the generators. It also allows the load on the Glen Lyn lines to be held at a predetermined value, without regard to the effect of this loading on the system frequency. Further, the system frequency may be held at a predetermined value while the Glen Lyn line load varies within predetermined limits, or the same condition applying to the load, the frequency may be held within predetermined limits. When this control scheme was first put into service, it was found that the response of the governing mechanism to the impulses of the frequency controller was so slow that the desired load change overshot the limit set. To correct this effect, a small motor has been attached to the gate-limit device on the governor, the motor being operated directly by impulses from the frequency-control equipment.

The Claytor plant was put into commission on August 1, 1939, and has operated under full head since April 20, 1940. As mentioned in the earlier part of this article, a 200,000-cusec flood occurred on the river in August, 1940. This was one and a third times the maximum flood which had previously been recorded. The whole of the equipment operated without a hitch, but the generating plant was necessarily run under a reduced effective head, owing to the heavy spillway discharge causing a rise in the tail-water level. During the four days of the flood, the plant generated 7,488,900 kWh, or an average of 75,645 kW. For the photographs and drawings illustrating these articles we are indebted to the American Gas and Electric Service Corporation of New York. The description is based on articles by Mr. Philip Sporn, vice-president and chief engineer of the Corporation, and Mr. H. A. Kammer, construction engineer, appearing in our contemporaries, the *Electrical World* and the *Engineering News-Record*.

THE CLAYTOR HYDRO-ELECTRIC POWER PLANT.

FIG. 9. 11,000-VOLT SWITCHGEAR CUBICLES.



THE AMERICAN PETROLEUM INDUSTRY.—The production of crude oil in the United States continues at a high level. During the week ended November 8, the output averaged 4,096,100 barrels daily, against 4,071,200 barrels in the preceding week.

INDUSTRIAL OVERALLS.—The provisional arrangement, made when rationing of clothing began, to ensure that workpeople should not have to go without essential overalls, has resulted in some unfairness. Some industrial overalls, such as boiler suits, have been supplied coupon-free while for others seven coupons have been required. In future, all industrial overalls will be available for two, three or four coupons each, according to type. The permission for various inspectors to certify the supply of overalls without coupons will now be withdrawn.

LITERATURE.

Fourier Series and Boundary Value Problems. By PROFESSOR R. V. CHURCHILL. London: McGraw-Hill Publishing Company Limited. [Price 17*s.* 6*d.*]

THOMSON AND TAIT'S contention that "Fourier's theorem is not only one of the most beautiful results of modern analysis but may be said to furnish an indispensable instrument in the treatment of nearly every recondite question in modern physics" remains as true to-day as when it was penned just over 60 years ago. In view of the wide significance of the methods first clearly formulated by J. B. J. Fourier, in 1822, in his classical *Théorie analytique de la Chaleur*, the number of books devoted mainly or exclusively to Fourier analysis is not large, and Professor Churchill's lucid and logical text is a welcome addition. An introduction containing the necessary definitions and basic theorems is followed by a chapter in which the fundamental partial differential equations that arise in connection with gravitational potential, conduction of heat, string and membrane vibrations are derived. The concept of orthogonal sets of functions is then discussed and its power exemplified in the possibility of representing an arbitrary function within a prescribed interval in

THE CLAYTOR HYDRO-ELECTRIC POWER PLANT, VIRGINIA, U.S.A.

(*For Description, see Opposite Page.*)

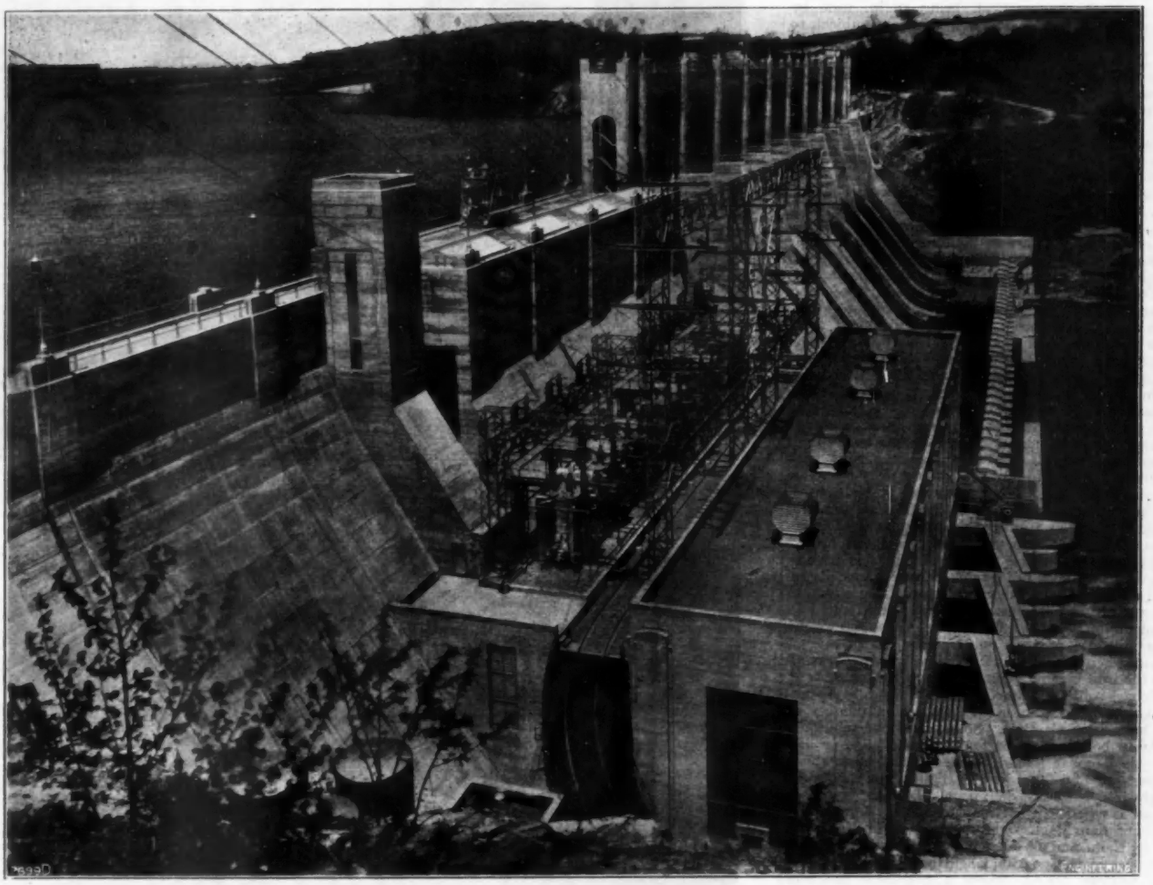


FIG. 11. EXTERIOR OF POWER HOUSE.

terms of a linear combination of such functions. To the most important special case—that of the representation of an arbitrary function by its Fourier series—the next chapter is devoted, and this is followed by an exposition of the properties of Fourier series and of the Fourier integral.

In mathematical physics a differential equation, taken in conjunction with the relevant boundary conditions, constitutes a boundary value problem, and the solution of boundary value problems by the use of Fourier series and integrals forms the subject of Chapter VI. The formal solution of problems of this sort is usually a fairly straightforward matter, but a satisfactory proof of the uniqueness of the solution arrived at in any particular instance often presents a more intricate problem. A preliminary account of some of the methods devised to establish the uniqueness of solutions is contained in the succeeding chapter. The last two chapters are devoted respectively to Bessel functions and Legendre polynomials and their applications. Adequate detail is given to enable their fundamental properties to be appreciated and to provide a rational basis for their employment in the solution of specific problems.

Professor Churchill has succeeded in keeping his treatment sufficiently elementary to serve as an introductory text and at the same time sufficiently rigorous to provide a sound basis for the more advanced treatment which he promises to provide in a subsequent work. Congestion in the text is avoided by relegating the proofs of certain intermediate stages in the analysis to the problems; one of several features that make the book one to be read with pleasure and consulted with profit.

SUFFOLK POST MILLS.*

By REX WAILES, M.I.Mech.E.

THE post mill is the earliest form of windmill known in Western Europe. In England the earliest surviving example, that at Bourn in Cambridgeshire, can be dated before 1636, while the last to be built outright seems to be Cross-in-Hand mill in Sussex, built by Medhurst, of Lewes, in 1855, moved to its present site in 1868, and still at work. Several post mills have been rebuilt after that date, the last probably being that at Wetheringsett, Suffolk, in 1881. The post mills of Suffolk form a complete study in themselves, and by the time that rollers began to take the place of stones for grinding, the typical Suffolk post mill could fairly claim to represent the ultimate development of its type, not only in England, but anywhere in the world.

The author was able, in 1937-39, to carry out an exhaustive technical survey of all the corn-grinding windmills of Suffolk for the Society for the Protection of Ancient Buildings and the Suffolk Preservation Society, who have permitted the results to be put at the disposal of the Newcomen Society. In eleven years, the number of working post mills had been reduced from 37 to ten, out of 18 still at work by wind in England in 1939. Seven of the Suffolk mills had been completely demolished and 20 had become derelict.

The typical Suffolk post mill has a "buck" (the Suffolk term for the body), painted white, mounted on a tall brick "roundhouse" with a boarded roof; it has four double-shuttered "patent" sails and a "fantail" mounted on a carriage attached to the bottom of the ladder giving access to the buck. The West Suffolk mills are shorter and squarer than those of East Suffolk, with lower roundhouses. Roundhouses were added to a number of mills, such as that at Framsden in 1836, and at Sweffling as late as 1901. Some mills, such as Horham, possessed none; but their advantage for storage and to protect the substructure of the mill from the weather is such that probably half of those examined were coeval with the mill. At Chippenhall Green, there was a wooden octagonal roundhouse, while Combs had a circular wooden one. Mendlesham had a roundhouse with a wall of clay lump, while Drinkstone, Parham, Rougham, Stradbroke, Syleham and Thurston mills have roundhouses with walls of flint and brick. The mill at Thorpeness was given a square roundhouse of concrete when moved to its present position from Aldringham in 1924. Drinkstone, Gedding, Haughley, Thorpeness and Wickhambrook mills have tiled roundhouse roofs. Inside they range from three-storey structures, as at Swilland, which is approximately 27 ft. in diameter and 25 ft. high, to those at Parham and Wenhaston mills, which are 20 ft. in diameter and 14 ft. 6 in. high.

Bucks vary in size considerably from Swilland, which has a floor approximately 20 ft. by 12 ft., and a height of 26 ft., to the "Kitty mill" at Wenhaston, which is 14 ft. by 9 ft. by 20 ft. high. Barley Green and Peasenhall mills have bulges at the sides to accommodate larger stones than were originally installed, and several mills, such as Woolpit, have special fixings on the roof ridge to accommodate the ropes when the mill is being painted from a cradle; but in no case are there the excrescences which are the rule in the Pas de Calais and the Nord departments of France. The normal framing of the buck consists of two horizontal "sidegirts" laid on the "crown tree," with a corner post at each end; but Barley Green, Drinkstone and Eye mills have no sidegirts and instead a vertical member is to be found at each end of the crown tree supporting the "upper and lower sidegirts." It is significant that Drinkstone is dated 1689, while Eye was built from an earlier mill. The largest sidegirts noted are at Swilland and are 12 in. wide by 16½ in. deep while the smallest are at Peasenhall, 5 in. wide by 11 in. deep. A number

* Paper read before the Newcomen Society, in London, on Wednesday, November 12, 1941. Abridged.

of sidegirts have cracked and have been "plated" by clamping or bolting a strengthening timber to them.

The "sheers" which run from front to back of the buck on either side of the post below the bottom floor are important members of the structure. The largest noted were at Stanningfield, being 16 in. wide by 9 in. deep. Like the sidegirts, they are subject to heavy stresses and sometimes crack and are plated, as at Parham, where sheers 10½ in. square are plated for the full length with 10½ in. by 6 in. timbers, each held with four straps and bolts.

"Crown trees," into which the posts socket and on which the sidegirts rest, vary in size from that at Haughley, 26 in. wide by 24 in. deep, to Drinkstone, 16 in. square. Like sidegirts, they are sometimes plated. Ashfield, 18 in. wide and 21 in. deep, is plated for the full width underneath, by 8 in. deep; Parham, 20 in. square, has a plate at the rear, 3½ in. thick by 15 in. deep by 54 in. long; Thornham Magna has a plate on the top, 3½ in. deep, and an iron plate below; Wickhambrook has a cast-iron angle, 19 in. by 19 in., ¾ in. thick and 72 in. long, and Drinkstone has a cast-iron Tee girder underneath. "Braces" or "sag-irons" are used to brace various parts of the structure to the crown tree. The sheers, lower sidegirts and front corner posts are most commonly treated in this way, and occasionally the rear corner posts. Wrought-iron rods, from ¾ in. round or square to 1½ in. in diameter, are employed, and strainers are often used in the diagonal braces to the corner posts.

The post, upon which the whole mill turns, is always the largest piece of timber in the mill. It tapers from the bottom, where it is always square, usually with chamfered corners, to the top, where it is round or multi-angular. The largest noted was at Halesworth—33 in. square, tapering to 24 in. in diameter, and the smallest was at Huntingfield, 20 in. square, tapering to 15 in. in diameter. The "sampson head," "grafil" or "capping" is general. This is usually an iron casting about 1½ in. thick, in two or four pieces, bolted up and fitted to the visible top of the post. It bears against a split cast-iron ring bearing, bolted to the bottom of the crown tree, and so takes the weight of the mill and prevents undue wear on the end of the post where it sockets into the crown tree. Sometimes the iron bearing is on the crown tree only, as at St. Michael South Elmham.

Posts, being of oak, often split and a number of them have been clamped. Sometimes four interlocking clamp bolts are to be found at the base, or just below the "collar" used to steady the buck about the post at first-floor level. If the top has split, wrought-iron rings are driven on. In some instances the post is cased in what may be termed a "corset," as at Thornham Magna, where eight wrought-iron bars, 3 in. by 2 in. and 66 in. long, are placed round the upper part of the post and held by five iron bands; or at Saxtead Green, where a two-piece cast-iron clamp is used, ⅞ in. thick and 30 in. long. Supporting the post are the two "cross trees" and the four diagonal "quarter-bars." Here again the largest noted were at Halesworth, 12 in. by 15 in. and 10 in. by 14 in., and the smallest at Huntingfield, 9 in. square and 7 in. square, respectively. In some cases knees are bolted to the cross trees against each of the four faces of the post, where it is mortised over the cross trees, to avoid any lateral movement.

The "bird-mouth" joint is usually relied upon to hold the quarter-bars on to the cross trees; but sometimes clamps were also used. Plating is found, as at Earl Soham, where the cross trees are plated at the ends and the quarter-bars are lined with wrought-iron strips. One feature frequently to be found is additional mortises in the post between the upper ends of the quarter bars. No one appears to be sure what their use was, but it seems possible that temporary struts were inserted, and served to hold the post upright while the quarter-bars were being fitted. At Hartest only, these additional mortises are below those cut for the quarter-bars, and are much larger than usual; it is possible that the post has come from some other mill or that this mill has been rebuilt or built from parts of another mill.

Only Drinkstone remains with a "tailpole" for turning it into the wind. To all others, a "fantail" has been fitted, the tailpole being sawn off and usually left just long enough to give some support to the ladder. The majority of fantails are mounted between two uprights which rise from a "carriage" fixed to the bottom of the ladder. The uprights are braced to the stringers of the ladder and the carriage has wheels, usually of iron, which run on a track round the mill. The drive is taken by means of bevel wheels from the horizontal fan spindle down through a vertical shaft to a horizontal shaft on the carriage, and one or sometimes both of the wheels are driven. If only one wheel is driven the drive is taken right across the carriage by a single horizontal shaft. If both are driven the shaft has to be split and a pair of very flat bevel wheels interposed, as the track wheels are set with their axles radially to the mill. In some cases, as at Swilland, worm drive to the wheels is used, in others, as at Stanningfield, there is an independent drive from the fan spindle to each wheel. A few fan carriages have wooden wheels, as at Woolpit and Wickhambrook mills. At the latter the fan carriage is fixed, not to the ladder, but to the end of the tail pole, which had not been sawn off short. At Woolpit, the fan carriage is fixed to both, the tailpole having been left long for the purpose and in some cases, as at Pettaugh, the tail pole has been removed completely and the ladder is braced to the buck with two wrought-iron stays. Monk Soham mill had a single driven iron wheel placed centrally in the fan carriage, while two small outrigger wheels supported, but did not drive, the carriage. In almost every case, provision was made for turning the mill round by means of a hand gear, should the wind fail. Fig. 1, herewith, shows the fantail carriage at Peasenhall. Only the left-hand wheel is driven. A remarkable feature is the "two-speed" hand drive, above the other wheel. Mills at Rishangles, Stanton Chair, Sweffling, Swilland and Wortham Ling had fantails on the roof of the buck and the drive was taken down to a worm-wheel mounted on the post just above the top of the quarter bars. All now have gone except Swilland, which has been converted to the more normal type of drive. The fans themselves usually had six vanes, though some had eight.

The typical Suffolk post mill has four double-shuttered "patent" sails revolving anti-clockwise, or right-handed when viewed from the front, though a few, such as Stanton Chair and the Horringer-road mill, Bury St. Edmunds, were left-handed. One or two had two double- and two single-shuttered right-handed sails, as at Worlingworth. Double-shuttered right-handed spring sails were to be found at Haughley and Brockley mills, and the same, but single-shuttered, at Badwell Ash; Monk Soham, Wrentham and the mill at Snape without a roundhouse had right-handed common sails. Two spring sails and two common sails could be seen at Drinkstone, Hartest, Hitcham, and Holton and Thornham Magna mills; all but the first and last were left-handed. There are usually three shutters to a "bay," or division of the sails by sail bars, though Huntingfield had four; seven or eight bays are the rule, but Hartest and Swilland mills have nine. A typical set of double-shuttered sails would be approximately 70 ft. span, 3 ft. 6 in. wide on the leading side, and 4 ft. 6 in. on the driving side, and the length of the sail frame would be about 30 ft. The "whips" on which the sail frames are built up would taper from about 6 in. by 7 in. at the centre to 5 in. square at the tip, and the stocks would be about 11 in. by 12 in. at the centre, and 45 ft. long. Many sails have "clamps" bolted on either side of the stocks to strengthen them, and these would be about 9 in. by 4½ in. in section and 10 ft. long. Shutters would be

SUFFOLK POST MILLS.

FIG. 1. FANTAIL CARRIAGE AT PEASENHALL MILL.

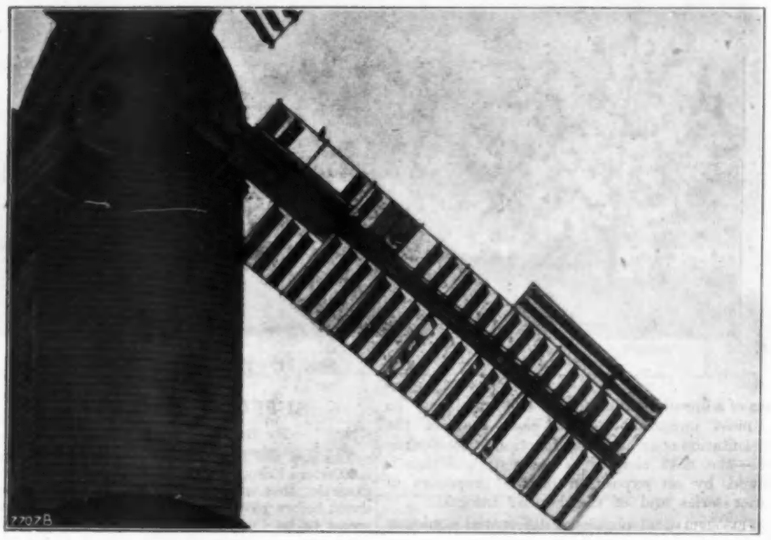


FIG. 2. CATCHPOLE'S SAIL AT GEDDING MILL.

SUFFOLK POST MILLS.

FIG. 2. CLASP-ARM BRAKE WHEEL AT PEASENHALL MILL.

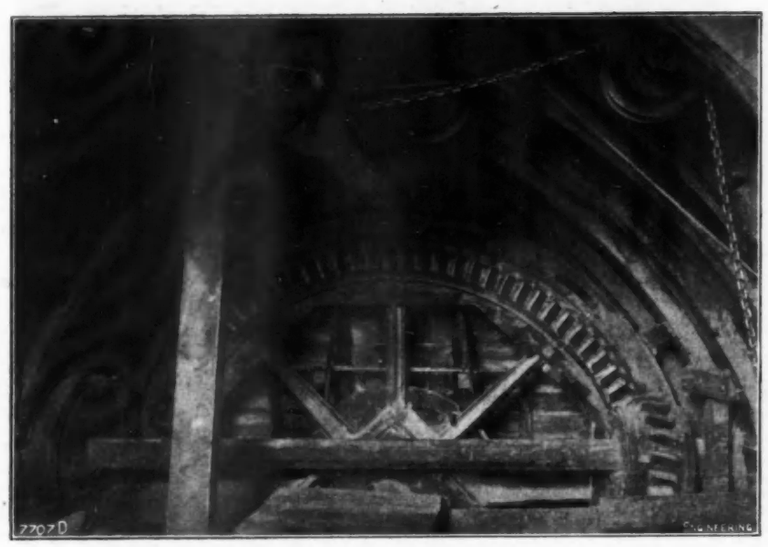


FIG. 4. BRAKE WHEEL AT PARHAM MILL.

12 in. wide and made of wood, or of canvas with wood or wire frames.

In general, the striking gear follows normal practice for patent sails, the method of operation being usually by a rack and pinion at the rear of the striking rod, operated by a chain which may be inside or outside the tail of the mill. In some cases, four chains are attached to a bar at the end of the striking rod and pass round a wooden roller having a rocking lever at the other end of its spindle, to which the normal type of operating chain is attached. A Suffolk peculiarity is Catchpole's patent sail; this is of the normal "patent" type with the addition of two pairs of longitudinal shutters, one behind the other, extending along the leading edge of the sail from the tip to a point about three bays in. When all the shutters are closed, these longitudinal shutters give additional driving power at the point where it is most effective. As the shutters open, the longitudinal shutters act as an air brake, spoiling the flow of air round the sails, and give much steadier running than is normally possible. They were fitted to the four double-shuttered sails on Gedding mill and to the two single-shuttered sails on Sibton mill. A sail of the former mill is illustrated in Fig. 2, opposite. The bird visible in the illustration is a pigeon, which gives some indication of the scale. This mill was moved from Felsham, 4½ miles away, in 1867.

The windshafts of the early mills were entirely of wood; to-day all the wooden shafts have iron "poll ends" through which the stocks of the sails pass, the original wooden ends having rotted or fretted. These poll ends usually have a cross-tailed gudgeon, which is let into the wooden shaft and held in place with wrought-iron bands, probably driven on. At Hartest, however, the poll is held on with an iron collar and coach screws; this shaft, incidentally, is the smallest noted, being 18 in. square at the brake wheel and 14 in. square at the tail wheel. Stanton is the largest, being 21 in. square at the brake wheel, and 15 in. across flats and 16-sided at the tail; the average is about 18 in. and 15 in., respectively. Drinkstone has a parallel shaft 18 in. in diameter and Haughley has what, for want of a better word, must be called "cogs" fixed to the shaft behind the tailwheel, to drive the jumper through a skew gear. Of iron shafts, the largest is at Briston and is 12 in. square at the brake wheel, with a neck 14 in. in diameter; while several mills, including Parham, put in in 1880-81, had small shafts, 8 in. square at the brake wheel and 5 in. square at the tail wheel. Halesworth has a two-piece shaft with a flange in front of the tail bearing; unusual in post mills, but more common in tower mills.

The material of a neck bearing is not usually seen, and information has to be taken on hearsay evidence; but, although the majority of bearings are of brass and were often made from old candlesticks, clock faces, pestles and mortars, etc., melted down, a number were of wood. Examples of these are at Drinkstone and Haughley, where apple wood is used. Thorpeness mill, when at Aldringham, had a hawthorn bearing; it now has a plum pillow-block with a square brass let in and wedged up from below so as to be about ¼ in. proud. Friston mill also has this arrangement, the brass being 4 in. square. It is said that the idea was that of Sil (Silas) Nunn, a well-known Suffolk millwright; it certainly saves a large amount of metal. Darsham mill had a 22-in. diameter neck journal to its windshaft, the largest yet noted in a windmill; it is unfortunate that other measurements were not taken before the mill was pulled down. When patent sails were fitted, this shaft was bored in position for the striking rod while the mill was at work, the operation taking three weeks.

Brake wheels, mounted on the windshaft, take their name from the fact that a contracting brake acts on the rim. The majority are of wood and of "clasp-arm" construction, with four arms forming a square at the centre through which the windshaft passes. The average size is about 8 ft. 6 in. in diameter, and the largest noted was at Darsham—about 10 ft. 6 in. in diameter. A number of mills have brake wheels as small as 7 ft. 6 in. in diameter; among them Woolpit, which has had a new rim fitted in front of the old one, and Peasenhall, shown in Fig. 3, herewith, which, though now a clasp-arm wheel, originally had an iron hub and arms. Examples of conversion to clasp arms from compass-arm construction (in which two arms were mortised through a wooden windshaft, weakening it where it needed most strength) were found at Barley Green, Gedding and Haughley mills. Some of the clasp-arm wheels are very heavy, with arms up to 11 in. deep, as at Wenhaston and Westhall mills, while the shape of the "cants" attached to the arms and carrying the rim vary considerably.

Parham as a 9-ft. wheel with an iron boss, eight T-section arms and a wooden rim, illustrated in Fig. 4, on this page; Tunstall had a 9-ft. iron wheel, cast in halves; and Wetheringsett, a 7-ft. wheel with eight T-section arms and an L-section rim. Stanningfield has an 8 ft. 3 in. diameter wheel with intermediate supports between the arms, while Sweffling had an 8-ft. diameter wheel, braced with iron.

The majority of these wheels are mounted on a square on the windshaft. Sometimes wood packing is used to fill up the space between the arms of the wheel and the shaft, and sometimes iron plates are fixed on either side of the centre of the wheel. At Ashfield, the windshaft has two flanges instead of a square, and steel angles are put across these as packing and support for the wheel. At Earl Soham, the brake wheel is mounted on a section of old wooden windshaft, through which the iron windshaft passes. In all cases, the wheel is hung on the shaft with keys and is trued up by this means. The teeth of these wheels were all at one time wooden cogs, crab, apple, hornbeam, beech, whitethorn, thorn acacia and oak being used; but in many cases these have been sawn off and iron teeth, cast in segments and bolted to the rim, have taken their place. The largest cogs were at Ashfield and Darsham mills, where they were 4-in. pitch. The smallest are 1½ in. pitch, at Drinkstone, but the pitches most used vary between 2 in. and 3 in.

The most curious teeth are to be seen at Peasenhall, where the 7 ft. 6 in.-diameter wheel, illustrated in Fig. 3, has iron skew teeth, cast in segments. These are made necessary by the fact that, on the upright shaft, the straight-toothed "wallower," which gears with the brake wheel, is mounted off-centre to it in order to accommodate two pairs of stones of somewhat unequal size, the larger pair being 4 ft. 10 in. in diameter and brought from elsewhere.

Eye, Friston, and Grundisburgh mills had two rings of cogs on their brake wheels, with about 12 in. difference in pitch diameter, and the inner ring an inch smaller in pitch. These inner rings provided the drive for the flour-dressing machines. The brake wheel at Stanton has an internal gear, cast in segments, for the same purpose. Brakes are usually of wood, though a few iron examples were noted. Elm was the timber usually selected on account of its resistance to burning, though willow was used at Halesworth, and poplar has also been used. At Hartest, however, there are two wooden brake segments at the top, 7 in. wide, 4 in. deep and 3 ft. 6 in. long, while the rest of the brake is of iron.

(To be continued.)

UNITED STATES COLLIERY INDUSTRY.—The production of bituminous coal in the United States during the week ending November 8 averaged 1,800,000 tons daily.

60-KVA WELDING MACHINE FOR PROJECTING PARTS.

THE spot and projection welder shown in the accompanying illustration is a recent example of the range of small special welding machines manufactured by Messrs. Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17; another welder in this range, of the same capacity, was described and illustrated in ENGINEERING, vol. 151, page 130 (1941). Except that the rating of the two machines is the same and both are adapted for handling materials of light gauge, they have different characteristics, the machine illustrated being capable of welding three or four projecting parts on to light gauge material simultaneously. The machine is also capable of welding studs on to flat surfaces and of producing a weld of about $\frac{1}{2}$ in. in diameter. No welding tools are shown in the illustration, so that the function of the machine is not obvious. The platens for the attachment of the tools, however, can be readily identified. These are similar to a machine tool table, having machined Tee-slots, but each has a central circular hole in accurate alignment so that standard tools provided with a spigot can be centred automatically without the help of a skilled setter. The Tee-slots in each platen are formed at right-angles to those of the other, this arrangement facilitating the alignment of any type of tool.

The top platen is attached to the ram of an air cylinder, but does not rely upon the working of the ram to maintain alignment during its stroke, this being effected by the sliding guide visible to the right of the platen. The bottom platen is formed with a knee bracket provided with a long slide and the height is adjustable, to suit different classes of work, by means of a screw and nut. The extended bearing surfaces for the slides are formed on the welded steel casing constituting the frame of the machine, and provide the rigidity necessary to maintain correct alignment of the tools both during a single operation and over a long period of use. In order to keep the general dimensions of the moving parts and platens within reasonable limits, they are water-cooled. The water supply is controlled by the small valve seen to the left of the casing. The final discharge is through the flexible tube seen behind the lower platen, this pipe leading to a fixed drain pipe on the front of the machine and fitted near the top with an opening through which the operator can observe the flow.

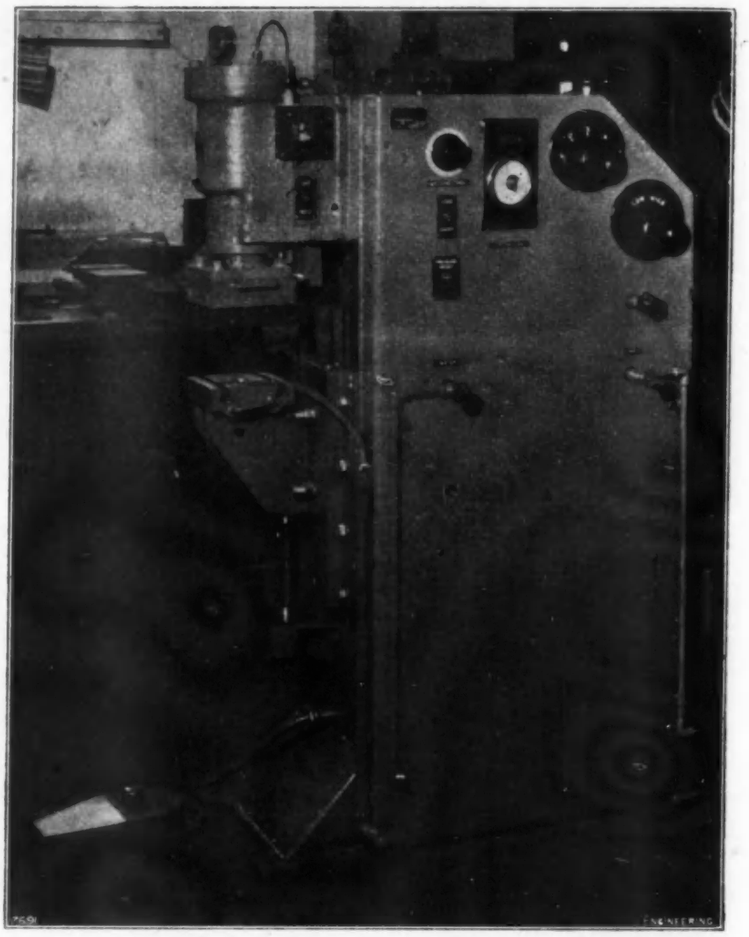
The object of an air-operated top platen is to vary the degree of pressure applied to the work during welding. The projections to be dealt with may be of different sizes on different jobs and a fixed pressure suitable for one projection might prove excessive for another. The air pressure is regulated by means of an adjustable reducing valve, so that the total load on the top platen can be varied. This load ranges from 600 lb. to 2,000 lb., and the pressure gauge on top of the cylinder is graduated to read this total pressure. The load control gear is interlocked with the electrical circuit by a pressure switch, so that the welding current is not switched on until the required pressure between the platens has been attained. In order to cover the range of thicknesses and number of projections which may be required, the welding current and time must be variable over a wide range in a manner analogous to the load variation. The machine is rated at 60 kVA, and it is capable of supplying a secondary current of 20,000 amperes. Two tapping switches on the transformer enable a 3 to 1 ratio between the maximum and minimum secondary voltage to be obtained. The duration of the welding current is regulated by a thyratron contactor timer which controls the duration from a minimum of 5 cycles to a maximum of 300 cycles. It is not always desirable to remove the platen load immediately the welding has been completed, and to obtain the necessary pause an adjustable delay period is provided by a synchronous mechanical timer, the dial of which is visible on the side of the machine.

The projection welding machine illustrated, which is known as Type ASP 60, has been designed to speed up production of this class of work without the necessity for highly-trained specialist operators, and to enable it to be carried out continuously and in a reliable manner. Naturally, no single machine can be constructed economically to cover the full range of projection welding, but in the present circumstances the lower end of the range is most important, hence the rated capacity of 60 kVA. At the same time, larger machines are under construction, the range extending to 1,250 kVA capacity.

CONTROL OF PARAFFIN OIL.—Under the Petroleum (No. 2) Order, 1941 (S.R. & O. 1941, No. 1711, price 1d.), it has become illegal for any dealer, or retailer, to sell paraffin oil (burning oil) as from December 1 unless he holds a licence issued by the Secretary for Petroleum authorising him to do so.

60-KVA WELDING MACHINE FOR PROJECTING PARTS.

MESSRS. METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.



THE "BRISTOL" HYDRAULICALLY-OPERATED AEROPLANE GUN TURRET.

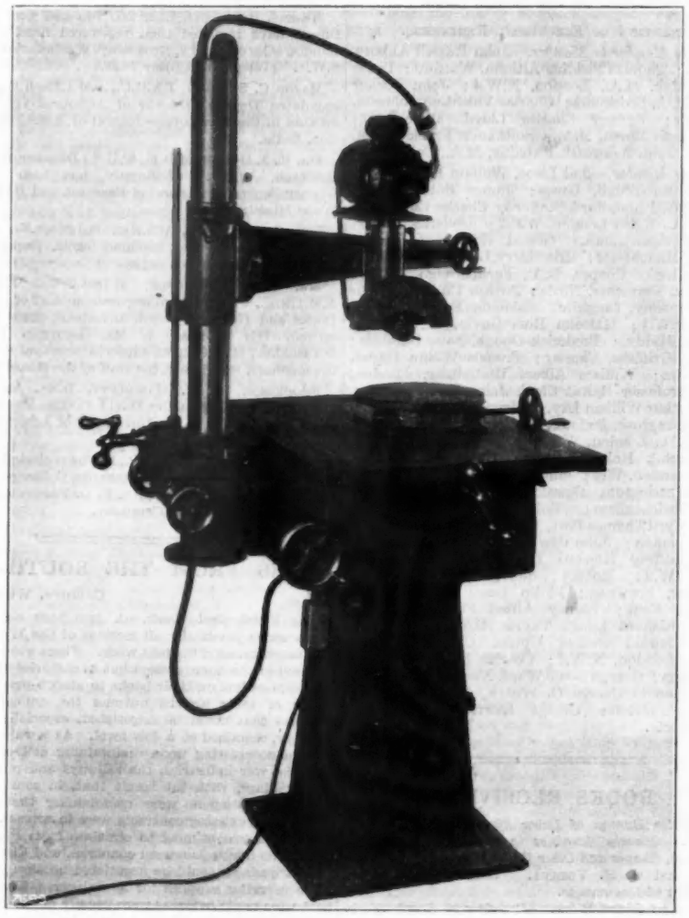
SINCE the power-operated gun turret has played, and is playing, so important a part in aerial warfare, the following notes, with the illustrations on page 450, describing some of the pioneer work in the development of such turrets, carried out by Messrs. Bristol Aeroplane Company, Limited, Bristol, will be of interest. The enclosed gun turret was designed to protect the gunner from the air flow at the high speeds of modern aircraft, and one of the first Bristol aeroplanes to be fitted with it was produced in 1930-31, the turret of this machine being mechanically operated. Hydraulic operation, however, was soon found to be preferable, particularly since this motive power is also convenient for such other services as operating retractable undercarriages, wing flaps, etc. The company accordingly proceeded with the design of a hydraulic control system. A research department was established for this purpose, and a satisfactory system was produced in 1935. The hydraulically-operated gun turret was worked out concurrently with the general gear, and was first fitted in a Bristol Bombay bomber-transport machine. In the following year, the first all-metal stressed-skin monoplane for the Royal Air Force was put into production. This machine was the Bristol Blenheim and had the gun turret amidships, an arrangement which proved to be of great value.

It was evident at the commencement of the research that the existing types of hydraulic pump had, in general, the defects of insufficient capacity and pressure for high-performance aircraft. The plunger-type pump was liable to set up pressure fluctuations of sufficient magnitude to cause breakages; the vane type was limited as to pressure; and the single-stage gear pump presented difficulties in that if the clearances were large enough to eliminate friction efficiency suffered, while if they were kept small to improve efficiency, there was a risk of seizure. Experiments were first made with a multi-stage gear pump, an early form of which is shown in Fig. 1. The U-shaped pipes seen at the front are the delivery pipes from one stage to the other. The efficiency of such a pump depends to a large extent on the continuity of the oil supply from one stage to the other, and this pump was designed so that the delivery from each stage exceeded the theoretical amount necessary, the excess being returned to the first-stage suction through a small adjustable relief valve fitted between each stage.

From this pump has been developed the present Bristol three-stage pump, which will give pressures of 1,500 lb. per square inch or more, with an output of 6 gallons per minute at normal engine revolutions. The pattern now in greatest production covers a range of pressures up to 1,200 lb. per square inch, with a delivery of 3 gallons per minute; it is known as the B.H. Integral type. One pattern of the production design, for flange-attachment to the engine casing, is shown in Fig. 3. The Bristol pump forms part of the auxiliary equipment for all types of aero-engines, including the water-cooled as well as the air-cooled radial types, both British and American. The first designs of the multi-stage pumps enabled operating pressures for the equipment to be increased from 300 lb. to 700 lb. per square inch, with a consequent reduction in the size and weight of the pipes and fittings. The last-mentioned pressure is that employed on the Bristol Blenheim, which was the first Royal Air Force aircraft to cross the German frontier in the war. The Bristol hydraulic system, we understand, is the only one operated as an open system, this arrangement avoiding the necessity for a "recuperator" or supplementary air pressure, the supply of which involves the use of auxiliary pumps, either power- or hand-operated.

PATTERN-MAKING MACHINE.

MESSRS. THE CRESCENT MACHINE COMPANY, LEETONIA, OHIO, U.S.A.



Research on the hydraulic system, apart from the solution of the pump problem, naturally extended to the design of jacks and rams for the operation of undercarriages, flaps, bomb-doors, gun turrets, etc., and a hydraulically-operated lock was also produced. This lock was first fitted on the retractable undercarriages of the Blenheim and operates automatically in both the "up" and "down" positions. The gun-turret mechanism involved extensive research. Electric motors and gears were first considered, but were not proceeded with. In 1935, the vane-type oil motor for turret rotation was investigated very thoroughly but was found to be unsuitable owing to the high pressure used. Jacks or rams were employed for limited angular movement, and a multi-cylinder motor for complete rotation. The first Bristol hydraulically-operated turret was on test early in 1936 and the simple control valve, illustrated in Fig. 2, was designed in connection with it. The valve consists of a cylindrical spindle with an arrangement of ports which gives fine control. Since the valve must be capable of being easily actuated under high hydraulic pressure, the load is taken off the ported part of the spindle and this is given a clearance of approximately half-a-thousandth of an inch in the body, the ends of the spindle being carried in ball bearings. This construction obviates the necessity of lapping operations, so that the unit is suitable for mass production by sub-contractors.

The first Bristol power-operated turret used on the Blenheim is shown in Fig. 4. This was a small turret, the ring being only 30 in. in diameter. The cupola was retractable, this motion being effected mechanically, and had a low drag which was largely attained by the use of a moving seat for the gunner, synchronised with the gun movement. There was a secondary motion of the column on which the gun was mounted. This could be operated independently to enlarge the field of fire and to cover such areas as could not be reached by normal rotation. The turret was originally fitted with one Lewis gun and, later, with a Vickers gas-operated gun. Still later, twin Browning guns were fitted, though in a different type of turret. An example of a twin-gun turret, operated entirely by hydraulic power, is illustrated in Fig. 5. The cupola is shaped differently from that of Fig. 4, but is not excessive in size. The makers claim that, generally, Bristol turrets are smaller and about half the weight of most other types with the same effectiveness, number of guns, supply of ammunition and field of fire. It is also claimed that they are the only successful turrets in which the gunner can also act as a wireless operator. This dual function presents considerable difficulties in design in order to provide accessible radio panels, etc., and to enable the operation of the wireless apparatus to be carried on while the gunner keeps a good look-out from the turret.

To fit a power-operated gun turret amidships in the fuselage is not a simple problem, as the gun must be prevented from firing through the aeroplane itself, or being damaged by contact with the fuselage. A restrictor gear was, therefore, devised, which enabled the gunner to rotate the turret at full speed without incurring these risks. Continuous improvement has been effected and the latest guns follow smoothly the contour of the fuselage without slowing down the rotational speed. The company has also developed a gun-mounting incorporating a "harmonisation gear," a shock-absorber system and quick-release mechanism. The former, though very simple, enables four guns to be lined up quickly and independently on the target. The quick-release device permits the guns to be removed instantly at the touch of a lever, while they are as easily replaced without handling anything but the gun itself, which is automatically locked in position when it is pushed home. On the other hand, the guns are readily accessible in the turrets without removing them from their mountings; thus, if one gun jams it can be cleared by the gunner. Ammunition boxes and containers can be easily replenished from the gunner's normal position.

The photographs of the gun turrets reproduced in Figs. 4 and 5 might give the impression that their complexity would render them difficult to manufacture and maintain, but the Bristol company have given special attention to the question of manufacture with ordinary engineering plant and without having to employ specially skilled labour. This policy has been maintained, and those parts which have to be interchangeable are made so that neither fine limits nor fine jigging set-ups are necessary, a procedure which is not only economical in time, but results in a comparatively low cost of manufacture. Easily-made adjustments are provided to counteract unavoidable discrepancies in manufacture and to render the turrets easy to install in the aircraft. Although the Blenheim machine has been most frequently mentioned, developments have also taken place in connection with other aircraft; for example, special nose and tail turrets were designed for the Bristol Bombay bomber-transport machine. Experimental and research work is proceeding to meet even more exacting requirements in the later types of aircraft, and still more powerful turrets are being evolved.

UNIVERSALLY-ADJUSTABLE PATTERN-MAKING MACHINE.

THE small pattern-making machine shown in the accompanying illustration has such a high degree of flexibility, owing to its numerous adjustments, that it should prove of considerable service in forming complicated core-boxes, etc., in the least possible time. The machine, which is described by the makers as the Multi-Form Patternmaker, is manufactured by Messrs. The Crescent Machine Company, Leetonia, Ohio, U.S.A. The cutter spindle is arranged to carry either a head having round-nosed cutters ranging from $\frac{1}{4}$ in. by $\frac{1}{4}$ in. to $1\frac{1}{4}$ in. by $\frac{1}{4}$ in.; a single fly cutter head with a range of from $2\frac{1}{2}$ in. to $4\frac{1}{2}$ in.; a four-blade head with a cutter range from $4\frac{1}{2}$ in. to 8 in.; or router bits of the same range as the round-nosed cutters. As will be evident from the illustration the spindle is driven by a Vee-belt from a motor mounted directly above it. The motor develops $\frac{1}{4}$ h.p. at 3,600 r.p.m., and the driving pulley is of the stepped type providing three spindle speeds of 3,600 r.p.m., 4,500 r.p.m., and 6,000 r.p.m., respectively. Belt-tensioning is effected by incorporating a spring in the motor mounting.

The working parts are carried on a pedestal base consisting of a single casting, well ribbed in order to resist vibration. The table is also strongly ribbed and has a machined surface 24 in. wide by 32 in. long. Both castings are artificially aged to eliminate internal stresses and so avoid the possibility of warping. The table has a longitudinal traverse of 24 in. in both directions; that is, it can be moved 12 in. on each side of the centre line. The movement is effected by a square-threaded screw with a crank-handle on each end of the table. The column carrying the arm on which the motor and cutter assembly is mounted can also be traversed in the direction of the table length. This traverse, of 12 in., is effected by a screw with a hand-wheel at each end. The relative displacement of the centre of the column and that of the table is, therefore, 24 in., thus rendering the machine suitable for long patterns or multiple patterns. In addition, the column can be rotated round its axis, so that the arc of the arm fully covers the table. This movement is effected by means of a worm and worm wheel gear carried in the traversing base and identified by the two small hand-wheels on the worm shaft. The column is provided with a locking device to set the arm in the desired angular position.

The column, which is of machined tool steel, is hollow to permit the passage of the cable to the motor and to accommodate a balance weight for the arm. It is provided with a flanged base swivelling on the traversing base and carrying a crank handle actuating the vertical traversing screw of the arm. A vertical traverse of 20 in. is provided and the sleeve carrying the arm can be locked in any position. The arm is mounted on the sleeve with a disc having a central pivot round which the arm can be rotated through an angle of 180 deg., this adjustment enabling the cutter spindle to be set either with its axis vertical or horizontal or at any angle between these positions. The motor and cutter assembly is carried on a saddle sliding on ways on the arm and having a traverse, by means of screw and handwheel, of 18 in. The subsidiary post carrying the assembly can be tilted in a vertical plane, as it is mounted in a sleeve which can be rotated on the saddle to permit of this swivelling adjustment. The post can be rotated in the sleeve on a vertical axis thus permitting adjustment of the cutter spindle so that it can be set, within limits, at any angle in a horizontal plane. These two movements are limited by the relation of the motor base plate to

the arm in the one case and by the relation of the belt drive to the arm in the other.

The degree of flexibility provided by the adjustments described above is augmented, for circular work, by the turntable seen in the figure. This is of machined cast iron and can be quickly attached to the main table. It can be rotated as desired by means of hand-operated precision worm gear. The standard equipment also includes a screw-cutting attachment with suitable centres and gears for cutting screws with pitches ranging from 1¼ in. to 5 in. Such screws may occasionally have to be cast for use as feed screws for mechanical stokers, etc. It is stated by the manufacturers that a screw pattern for a stoker was cut on the machine in 3 hours, as compared with 30 hours required for hand work. Other equipment comprises a cutter grinding attachment for round-nose cutters, a grinding wheel, a chuck, hold-downs and cutter guards. The overall height of the machine is 6 ft., and the height of the table surface from the floor is 3 ft. 0½ in. The floor space occupied is 3 ft. 4 in. by 5 ft. 7 in., but the machine is also made for bench mounting.

DIRECTORATE OF INDUSTRIAL ELECTRICAL EQUIPMENT AREA ORGANISATION.

On page 390, *ante*, we gave some particulars of the formation of the Directorate of Industrial Electrical Equipment of the Ministry of Supply and we quoted the names of the Electrical Advisory Panel set up to give the Directorate advice and assistance. We are now informed that the Director of Industrial Electrical Equipment has set up an area organisation the aim of which will be to render help and advice to war factories in matters arising out of damage, by enemy action, to industrial electrical equipment. An electrical adviser has been appointed in each of the Defence Areas and several electrical engineers, in each area, have placed their services at the disposal of the adviser to act as his assistants in case of need. All these engineers serve in an honorary capacity. The area organisations have undertaken, on behalf of the Directorate, a survey of the electrical repair capacity and of the stocks of electrical equipment which could be called upon in an emergency. Close collaboration is maintained with the Machine Tool Control Area and Repair Organisation, the Ministry of Aircraft Production Emergency Services Organisation, and the Ministry of Works and Buildings Emergency Works Department. The services of the electrical advisers and their assistants are available through these organisations.

The names and addresses of the area electrical advisers are as follow:—Defence Area No. 1 (Northern) Mr. J. Clement, Messrs. The British Thomson-Houston Company, Limited, Ellison-place, Newcastle-upon-Tyne, 1; Area No. 2 (East and West Riding) Mr. L. G. Bryden, Messrs. Crompton Parkinson, Limited, 4-6, New York-road, Leeds; Area No. 3 (North Midland) Mr. B. Gill, Messrs. The Midland Dynamo Company, Limited, 64, Belgrave-gate, Leicester; Area No. 4 (Eastern) Mr. J. H. Enion, Messrs. The Igranic Electric Company, Limited, Bedford; Area No. 5 (London & South Eastern) Mr. A. W. Berry, Messrs. Crompton Parkinson, Limited, Electra House, Victoria-embankment, London, W.C.2; Area No. 6 (Southern) Mr. M. G. R. Elliott, Messrs. Lancashire Dynamo & Crypto, Limited, 94, Petty France, London, S.W.1; Area No. 7 (South Western) Mr. A. H. Topham, Messrs. Mawdsley's, Limited, Dursley, Gloucestershire; Area No. 8 (Wales) Mr. H. Coope, Messrs. Metropolitan-Vickers Electrical Company, Limited, Mervyn House, Frederick-street, Cardiff; Area No. 9 (Midland) Mr. T. G. Travis, Messrs. The General Electric Company, Limited, Witton, Birmingham, 6; Area No. 10 (North-Western) Mr. J. I. Law-Brooks, Messrs. Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17; Area No. 11 (Scotland) Mr. G. S. Helme, Messrs. Lancashire Dynamo and Crypto, Limited, 80, Blythswood-street, Glasgow; and Area No. 12 (Electrical Adviser to Northern Ireland Ministry of Commerce) Mr. H. W. Richardson, District Admiralty Electrical Engineer, Messrs. Harland and Wolff, Limited, Queen's Island, Belfast.

CONFERENCE ON AIR-RAID PRECAUTIONS IN THE ENGINEERING INDUSTRY.—With the co-operation of the Ministry of Home Security (Research and Experiments Department), the Institutions of Civil, Mechanical and Electrical Engineers have arranged a special whole-day conference on "Air-Raid Precaution Measures and the Engineering Industry," to be held on Tuesday, December 9, at the Central Hall, Westminster, London, S.W.1. Admission to the Conference is restricted to corporate members of the three Institutions concerned, who must apply, in writing, to the respective Secretaries for tickets, which are not transferable. It will not be possible to permit the attendance of non-ticket-holders who seek admission at the door.

INSTITUTION ELECTIONS.

INSTITUTE OF MARINE ENGINEERS.

Member.—T. W. Bunyan, Carshalton; W. J. Frier, Meols, Cheshire; E. Other, Belfast; W. Szafranski, London, S.W.3; J. S. Wells, Hornchurch, Essex; E. T. Walcroft, Horwich, near Bolton, Lancs.

INSTITUTION OF ELECTRICAL ENGINEERS.

Associate Member to Member.—John Russell Abbott, Blackpool; Thomas Fielding Altham, Watford; Leslie Baines Haigh, M.A., London, N.W.4; John Barker Hartley, M.C., Stockport; Charles Valentine Johnson, Manchester; Sydney Charles Lloyd, Manchester; Nevill Francis Marsh, M.A., Grantham; Frank Mason, Sheffield; John Ashworth Ratcliffe, M.A., Cambridge.

Associate Member.—2nd Lieut. William Henry Agar, R.A.O.C., Burscough, Lancs; James Bathie, Edinburgh; Alfred Blandford, Stafford; Charles Edward R. Bruce, M.A., B.Sc., London, W.C.2; Frederick Butler, B.Sc., Sleaford, Lincs.; Gerald William G. Cogle, Stretford, Manchester; Eric Harry L. Cooper, Rugby; William Charles Cooper, B.A., Farnborough, Hants; Harry Cox, Bramcote, Notts; Arthur Charles Ehrenberg, Timperley, Cheshire Solomon English, D.Sc., London, S.W.1; Malcolm Ross Gavin, M.A., B.Sc., Wembley, Middx.; Frederick Gough, Sale, Cheshire; Elis Wyn Griffiths, Chester; Francis Willim Hayes, Birmingham; William Albert Humphries, London, S.W.3; Professor Ransit Singh Jain, B.Sc., Benares, India; Arthur William Lay, Chelmsford, Essex; Leslie Wilfred Lovegrove, Oxford; Robert Winstanley Lunt, M.Sc., Ph.D., London, W.12; Tom Reginald Lupton, M.Sc. (Tech.), Hale, Cheshire; George William G. Mackie, London, W.4; James Joseph McMullen, B.Sc. (Eng.), Warrington; Oswald Edwin Mainer, B.Sc. (Tech.), Twickenham; Roland Matthews, Enfield, Middx.; Cyril Thomas Port, Darlington; John Stanley Raven, London; John Irwin Shuttleworth, Carmarthen; Geoffrey Howard L. Smith, B.Sc. (Eng.), London, W.8; Robert Squire, Cossington, near Bridgwater, Somerset; Philip Rowe Stevens, B.Sc., Meopham, Kent; Sidney Alfred Strode, Ashford, Middx.; Richard Lough Taylor, B.Sc., Chelmsford, Essex; Oswald Stokes Upton, Cardiff; Laszlo Urmenyi, London, N.W.3; Charles Frederick Wade, Birmingham; George Louie Ward, Northwood, Middx.; Captain Ronald George O. Wearn, Aldershot; Fred Williams, Preston; George Lawrence Woodward, Barnet, Herts.

BOOKS RECEIVED.

United States Bureau of Labor Statistics. Serial No. R.1337. *Hourly Earnings in the Making of Wood Turnings, Shapes and Other Wood Products.* By V. S. BARIL and O. E. VOTAVA. Washington: Superintendent of Documents.

Aircraft Sheet Metal Work. Repair and Bench Work. By H. E. BOGGESS. London: Sir Isaac Pitman and Sons, Limited. [Price 7*s.* 6*d.* net.]

Annual Reviews of Petroleum Technology. Volume 6 (Covering 1940). DR. F. H. GARNER, Editor. The Institute of Petroleum, c/o The University of Birmingham, Edgbaston, Birmingham, 15. [Price 11*s.* net.]

Practical Sheet and Plate Metal Work. By E. A. ATKINS. Fifth edition. Revised by W. A. ATKINS. London: Sir Isaac Pitman and Sons, Limited. [Price 8*s.* 6*d.* net.]

United States Bureau of Mines. Minerals Yearbook. Review of 1940. Prepared under the direction of E. W. PEHRSON. H. D. KEISER, editor. Washington: Superintendent of Documents. [Price 2 dols.]

The Ohio State University. The Engineering Experiment Station. Circular No. 41. *Public Water Supplies and Control of Stream Pollution in Ohio.* By F. H. WARING. Columbus, Ohio, U.S.A.: The Engineering Experiment Station, The Ohio State University.

Aircraft Diesels. By P. H. WILKINSON. London: Sir Isaac Pitman and Sons, Limited. [Price 30*s.* net.]

United States Geological Survey. Bulletin No. 908. *Geology of Area Between Green and Colorado Rivers, Grand and San Juan Counties, Utah.* By E. T. MCKNIGHT. Washington: Superintendent of Documents. [Price 1.50 dols.]

United States Geological Survey. Water-Supply Paper No. 869. *Flood of August,* 1935, *in the Muskingum River Basin, Ohio.* By C. V. YOUNGQUIST and W. B. LANGBEIN. *With Sections on the Associated Meteorology and Hydrology.* By W. E. SMITH and A. K. SHOWALTER. Washington: Superintendent of Documents. [Price 40 cents.]

Operational Methods in Applied Mathematics. By PROFESSOR H. S. CARSLAW and J. C. JAEGER. London: Oxford University Press (Humphrey Milford.) [Price 17*s.* 6*d.* net.]

The Physics of Blown Sand and Desert Dunes. By R. A. BAGNOLD. London: Methuen and Company, Limited [Price 24*s.* net.]

PERSONAL.

MESSRS. BRAITHWAITE AND COMPANY, ENGINEERS, LIMITED, The Moorings, Church Road, Great Bookham, Surrey, have acquired a temporary London office at 23, Kings House, Haymarket, S.W.1. (Telephone WHItehall 3993.)

MESSRS. BALDWINS, LIMITED, iron and steel manufacturers, have removed their registered head office and London sales office to 6, Broadway, Westminster, London, S.W.1. (Telephone ABBey 1853.)

MAJOR C. S. BOYD, I.A.O.C., A.M.I.Mech.E., has been appointed Deputy Director of Armoured-Vehicles Production in the Directorate-General of Munitions Production, India.

DR. H. J. GOUGH, M.B.E., F.R.S., Director of Scientific Research, Ministry of Supply, has been appointed Deputy Controller General of Research and Development in the Ministry.

MR. C. W. BUDD, Wh.Ex., M.I.Mech.E., has been appointed Director of Machine Tools, Department of Supply, Government of India.

MR. T. L. NORFOLK, M.Inst.C.E., M.I.Mech.E., A.M.I.E.E., who has been engineer-in-chief of the Mersey Docks and Harbour Board, Liverpool, since 1928, has retired. His successor is MR. LEOPOLD LEIGHTON, M.Inst.C.E., M.I.Mech.E., hitherto principal assistant to the engineer, who joined the staff of the Board in 1914.

PROFESSOR E. W. MARCHANT, D.Sc., M.I.E.E., is shortly to retire from the David Jardine Chair of Electrical Engineering of the University of Liverpool, which he has occupied since 1903.

MAJOR G. D. MAYHEW, J.P., has been elected a director of Messrs. Amalgamated Anthracite Collieries, Limited. He has succeeded the late MR. E. O. FORSTER BROWN as technical adviser to the Company.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—A firm tone continued to characterise practically all sections of the Welsh steam-coal market during the past week. There was a sustained demand in the home section but as collieries already had sufficient orders on their books to absorb practically the whole of their present outputs the amount of new business that could be negotiated, especially for early delivery, remained at a low level. As a rule producers were concentrating upon maintaining deliveries to the essential war industries, the railways and public utility undertakings, with the result that, in some instances, ordinary customers were complaining that deliveries under their existing contracts were in arrears. A fairly good inquiry continued to circulate from Portugal and Spain, the South American countries, and Eire, but little export business could be negotiated because of the need for conserving supplies for home users. The deliveries that were made overseas were usually of the low-volatile classes which were of little interest to home users. Best large descriptions moved off steadily under existing commitments and there was a brisk demand for the sized grades; drysteam sorts were scarce. The strongest feature of the market was presented by bituminous smalls which were in active request but were almost entirely stemmed for a long time to come. On the other hand, there was an ample supply of the dry steam small classes for early delivery and the tone was dull. Cokes were active and strong; patent fuel was steady.

CONTROL OF EXPORTS.—The Board of Trade has issued the Export of Goods (Control) (No. 41) Order, 1941 (S.R. & O. 1941, No. 1886, price 1*d.*), which came into force on December 1. The terms of this Order make it clear that the requirement of an export licence for the shipping overseas of iron and steel castings, forgings, stampings and pressings does not extend to such machinery parts as are not covered by other headings in the Export Control list.

EAST MIDLAND ELECTRICITY DISTRICT.—Under the provisions of section 7 of the Electricity (Supply) Act, 1919, the Electricity Commissioners made an Order entitled the East Midlands Electricity District Order, 1924, establishing the East Midlands Electricity Advisory Board. Owing to the change in the circumstances of the East Midlands Electricity District, the Commissioners consider it to be expedient that the Board should cease to function and be dissolved. Accordingly a draft Order providing for this step has been published. A local inquiry in respect of the draft Order will, however, be held at the Guildhall, Nottingham, on Wednesday, December 17, at 2.30 p.m. Copies of the draft Order may be obtained on application to the Secretary, Electricity Commissioners, Savoy Court, Strand, London, W.C.2, and any representations or objections with regard to its provisions should be submitted in writing to the Secretary of the Commission not later than December 11.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Increasing outputs are reported by all branches of the Sheffield iron and steel industry. In the lighter trades, production has increased during the past year as a result chiefly of the introduction of more women workers. There is an abnormal demand for basic steels. Melting plant is operating at full capacity in all the large works, and additional furnaces have been installed. At some works steps are being taken to reconstruct furnaces so that they can take larger charges. One concern has reconstructed a 60-ton furnace to take a charge of 90 tons. An increasing tonnage of acid steel is also going into consumption. Rolling mills, forges, and foundries are all operating at high pressure. Re-rollers are experiencing difficulty in coping with the orders they have received. There is little change in the heavy machinery and engineering trades. Business is still brisk, and outputs have been well maintained. There is a steadily-expanding demand for steelworks' and iron-works' machinery and similar plant. Sheffield works are turning out a heavy tonnage of forgings and castings of large size and weight. Producers of railway rolling stock are busier, and Sheffield works are delivering an increasing tonnage of steel forgings, castings, auxiliary machinery, and all types of deck furnishings to naval and mercantile shipbuilding yards in various parts of the country. Makers of electrical equipment are maintaining their satisfactory position; mining equipment is also a progressive line. Makers of agricultural machinery and parts have well-filled order books, despite the fact that the seasonal demand is not yet under way. Outputs of high-efficiency steels have been expanding during the past few months, and have now reached a level unsurpassed in Sheffield's industrial history. Engineers' small tools are in strong demand, and there is a heavy demand for machine tools.

South Yorkshire Coal Trade.—All classes of coal are moving freely. Industrial coal, especially sorts consumed by iron and steel works, is in strong demand. The consumption of steams has increased, and the demand for locomotive coal has been more than maintained. Smalls and slacks are in request by power stations. The house-coal market is satisfactory; householders are buying freely and there are few complaints regarding deliveries. Foundry and furnace cokes are active.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The past month has been an exceptionally busy one in the Scottish steel trade. The demand for plates continues. The shipyards are taking an increasing tonnage and makers are experiencing strong pressure for deliveries. The production has been increasing steadily, with the result that all calls are being satisfactorily met. Boiler plates are in strong demand and specifications for special steels for armaments have been steadily increasing. Medium plates are moving freely but light plates are not so active. Makers of black-steel sheets are fairly well employed although export business is not very extensive. Supplies of raw materials are quite satisfactory at present. Prices are steady and are as follows:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black-steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—Conditions in the West of Scotland malleable-iron trade show little change and although there is a fairly steady demand from some consumers the general demand is not particularly heavy. Supplies of raw materials are sufficient for current requirements. The re-rollers of steel bars report an increased demand and are fairly well off for business. Orders have been coming in steadily during the past week. Ample stocks of semies are now available. The following are the current quotations:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—The Scottish pig-iron industry is still active and, although the present output is at a maximum, makers are finding it difficult to meet the demand. Consumers are so busy that they have been forced to make use of the reserves they have accumulated and are now pressing for deliveries to ensure continuity of production. The demand for foundry iron is strong. Stocks of raw materials are satisfactory. To-day's market quotations are as follows:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both quotations being for iron on trucks at makers' yards.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Raw materials are abundant and apart from hematite, the use of which is still officially restricted, pig iron is plentiful, delivery licences being freely obtainable for forge, foundry and refined descriptions. Semi-finished products are in ample supply and the distribution of most finished commodities covers all requirements of national importance. The demand for special alloy steels, however, exceeds the supply and a further increase in output is necessary. Business is quiet as contracts now in hand will absorb nearly the whole of the iron and steel delivery allocations to the end of the year.

Cleveland Iron Trade.—The continued shortage of Cleveland pig is of little consequence. The activity at light foundries is reviving slowly and deliveries of Midland iron are sufficient for general requirements. Several sources of supply are open to foundry-iron consumers, who need particular qualities of pig for certain special purposes. The stabilised values of Cleveland pig remain at the level of No. 3 quality at 128*s.*, delivered within the Tees-side zone.

Basic Iron.—The output of basic iron is rather more than sufficient for the heavy requirements of the makers' own steel-producing plants, but enables only small additions to emergency stocks. The nominal fixed price of basic iron remains at 120*s.* 6*d.*

Hematite.—Stringency in the hematite branch of trade is slowly but steadily diminishing. The inadequate make still necessitates drastic restriction of distribution and prospects of a material increase in production are still remote. The recognised market values of hematite are ruled by No. 1 grade of iron at 138*s.* 6*d.*, delivered to North of England areas.

Foreign Ore.—Foreign-ore consumers are carrying good working stocks of most qualities, but descriptions required for hematite-making are still in short supply.

Blast-Furnace Coke.—Values of Durham blast-furnace coke are firm, though the demand is quiet. Local users are well supplied and are not inclined to discuss new business. Sellers have control of a considerable tonnage, but have extensive contracts to carry out and are not anxious to book further orders. The fixed prices are based on good medium qualities at 36*s.* 9*d.* f.o.r.

Manufactured Iron and Steel.—Stocks of semi-finished iron and steel remain at a satisfactorily high level and ensure the maintenance of full activity at the re-rolling mills. The consumption of semies is likely to increase, but the larger delivery of home products is expected to compensate for the suspension of supplies from overseas. Orders for heavy descriptions of material provide most of the work being done by manufactured-iron firms. The distribution of black and galvanised sheets is sufficient for the heavy demand; the supply of shipbuilding requisites is satisfactory and the orders for tank plates are receiving careful attention. The demand for special alloy steels continues to increase and necessitates a prompt enlargement of the output.

Scrap.—Although extensively bought, users of heavy iron and steel scrap are anxious to place orders, but consumers of light varieties have largely covered their requirements.

THE CONTROL OF MACHINE TOOLS.—The Minister of Supply has issued the Control of Machine Tools (Electrical Equipment) (No. 1) Order, 1941. Its purpose is to introduce a measure of standardisation for electrical equipment for machine tools in order to facilitate the flow of production. Special specifications, preferences for particular makes of equipment, and in particular the widely varying conditions imposed by the local electric-supply authorities, have all hampered the efficient planning of supplies of electrical equipment for machine tools. In view of this the Order provides, firstly, that all such electrical equipment, manufactured in the United Kingdom after January 1, 1942, shall comply with British Standard Specifications; secondly, that indicating instruments shall not be fitted unless they are essential to the efficient operation of a machine tool. It is provided, in the third place, that electric-supply authorities shall not refuse to supply electricity to users requiring to start, direct-to-line on a three-phase system, a motor of a capacity not exceeding 5 h.p.; or requiring to use, on such a system, a squirrel-cage motor of a capacity not exceeding 30 h.p. Finally, it is laid down that no person, by virtue of any contract, shall be entitled to demand delivery of electrical equipment produced by a specified maker or of a specified brand, or to require the equipment to be subjected to any test other than is necessary to establish compliance with British Standard Specifications. Tests required by the machine-tool makers are excepted from this provision. It is pointed out that the Order does not apply to electrical equipment for use on board any ship or vessel.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Meter and Instrument Section:* To-day, 4 p.m., Savoy-place, Victoria-embankment, W.C.2. "Maximum Demand Metering: A Study of the Timing and Length of the Integration Period," by Mr. D. J. Bolton. *North-Western Centre:* Saturday, December 6, 2.30 p.m., The Engineers' Club, Albert-square, Manchester. "Outdoor Bushings: Their Construction, Testing and Standardisation," by Mr. W. A. Cook. *North Midland Students' Section:* Saturday, December 6, 2.30 p.m., The Hotel Metropole, King-street, Leeds. The Students' Lecture: "The Failure of the Technician in His Role as Citizen," by Dr. D. S. Anderson. *North-Eastern Centre:* Monday, December 8, 6.15 p.m., The Neville Hall, Newcastle-upon-Tyne. "Space Heating by Electrically-Warmed Floors," by Mr. R. Grierson. *Scottish Centre:* Tuesday, December 9, 6 p.m., The Royal Technical College, Glasgow, C.1. "Electricity Applied to Medicine," by Dr. A. B. Maclean. *Transmission Section:* Wednesday, December 10, 5 p.m., Savoy-place, Victoria-embankment, W.C.2. "The Measurement of Lightning Voltages and Currents in Nigeria, II, 1938–39," by Messrs. F. R. Perry, G. H. Webster and P. W. Baguley. *Installations Section:* Thursday, December 11, 5 p.m., Savoy-place, Victoria-embankment, W.C.2. "Rationalisation of Colliery Electrical Equipment," by Mr. J. A. B. Horsley. *North Midland Centre:* Saturday, December 13, 2.30 p.m., The Hotel Metropole, King-street, Leeds. "Metal Rectifiers," by Dr. A. L. Williams and Mr. L. E. Thompson.

INSTITUTION OF CIVIL ENGINEERS.—*Yorkshire Association:* Saturday, December 6, 2.30 p.m. The Royal Victoria Station Hotel, Sheffield. "Mining Subsidence and Some Drainage Problems Arising Therefrom," by Mr. H. J. Paul. *Institution:* Tuesday, December 9, 10.45 a.m., 2 p.m., and 3.30 p.m., The Central Hall, Westminster, S.W.1. Joint Meeting with THE INSTITUTION OF MECHANICAL ENGINEERS and THE INSTITUTION OF ELECTRICAL ENGINEERS. Whole-Day Conference on "Air-Raid Precaution Measures and the Engineering Industry." (For Corporate Members only: see also paragraph on page 448.)

INSTITUTION OF MECHANICAL ENGINEERS.—*Western Branch:* Saturday, December 6, 2.45 p.m., The Royal Hotel, College Green, Bristol. Presidential Address: "The Position of the Locomotive in Mechanical Engineering," by Mr. W. A. Stanier. (To be preceded by an informal luncheon at 1.15 p.m.) *South Wales Branch:* Saturday, December 13, 12.30 p.m., Mackworth Hotel, Swansea. Luncheon Meeting. The Thomas Lowe Gray Lecture, by Major William Gregson. *Southern Branch:* Saturday, December 13, 2 p.m., Polygon Hotel, Southampton. Presidential Address: "The Position of the Locomotive in Mechanical Engineering," by Mr. W. A. Stanier. (To be preceded by a lunch.)

INSTITUTION OF PRODUCTION ENGINEERS.—*Coventry Section:* Saturday, December 6, 4 p.m., The Canteen, Messrs. Humber Limited, Coventry. Discussion on "Surface Finish," by Dr. G. Schlesinger. *London Section:* Friday, December 12, 3 p.m., The Institution of Mechanical Engineers, Storey's-gate, S.W.1. "Sampling Inspection and Quality Control," by Dr. B. P. Dudding. *North-Eastern Section:* Friday, December 12, 6.15 p.m., The County Hotel, Newcastle-upon-Tyne. "Drop Forgings," by Mr. A. Chilton.

INSTITUTION OF THE RUBBER INDUSTRY.—*London Section:* Monday, December 8, 6 p.m., Caxton Hall, Westminster, S.W.1. "Symposium on Sponge Rubber."

INSTITUTION OF CHEMICAL ENGINEERS.—Tuesday, December 9, 2.30 p.m., The Geological Society's Rooms, Burlington House, Piccadilly, W.1. Joint Meeting with the *Chemical Engineering Group* of THE SOCIETY OF CHEMICAL INDUSTRY. "A New System of Double Filtration for Sewage," by Dr. A. Parker.

INSTITUTE OF TRANSPORT.—Wednesday, December 10, 1 p.m., Connaught Rooms, Great Queen-street, W.C.2. Luncheon and Address by Mr. H. E. Clay.

NEWCOMEN SOCIETY.—Wednesday, December 10, 2 30 p.m., The James Watt Memorial Institute, Birmingham, 3. Ordinary Meeting. (i) "History of Spring Balances," by Mr. W. A. Benton. (ii) "Origin and Manufacture of Wood Screws," by Dr. H. W. Dickinson.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, December 12, 6 p.m., The Mining Institute, Newcastle-upon-Tyne. "Plastics and Engineering," by Dr. A. Caress.

JUNIOR INSTITUTION OF ENGINEERS.—Saturday, December 13, 2.30 p.m., 39, Victoria-street, S.W.1. Induction of Lord Sempill as President.

MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday, December 13, 2.30 p.m., The Engineers' Club, Manchester. "The Manufacture of Articles from Powdered Metals," by Dr. W. D. Jones.

HYDRAULICALLY-OPERATED AEROPLANE GUN TURRETS.

MESSRS. BRISTOL AEROPLANE COMPANY, LIMITED, BRISTOL.

(*For Description, see Page* 446.)

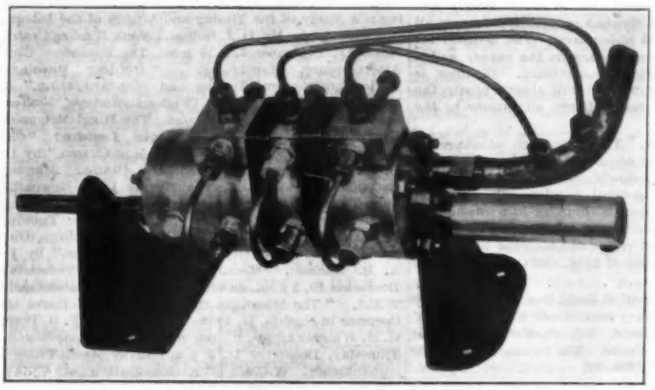


FIG. 1. EARLY FORM OF MULTI-STAGE GEAR PUMP.

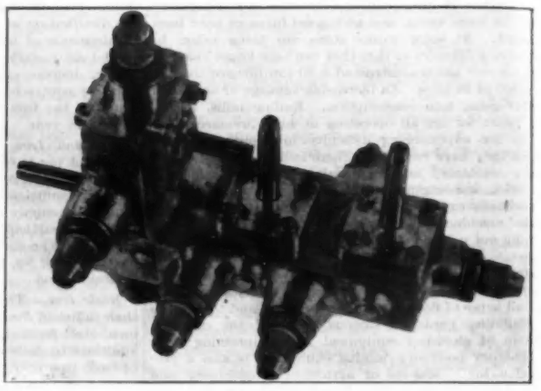


FIG. 2. CONTROL VALVE OF HYDRAULIC SYSTEM.

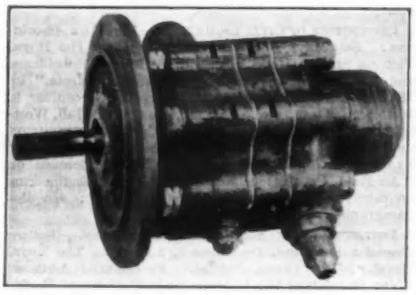


FIG. 3. MULTI-STAGE PUMP. B.H. INTEGRAL TYPE.

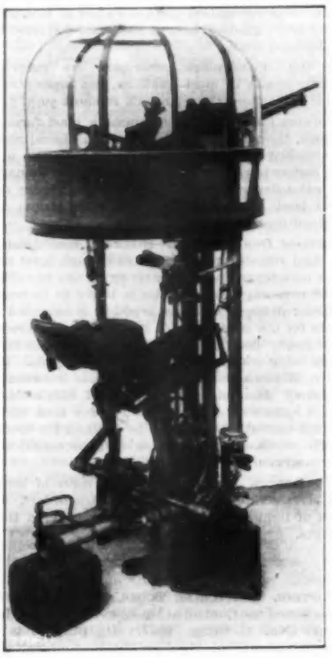


FIG. 4. SINGLE-GUN TURRET.

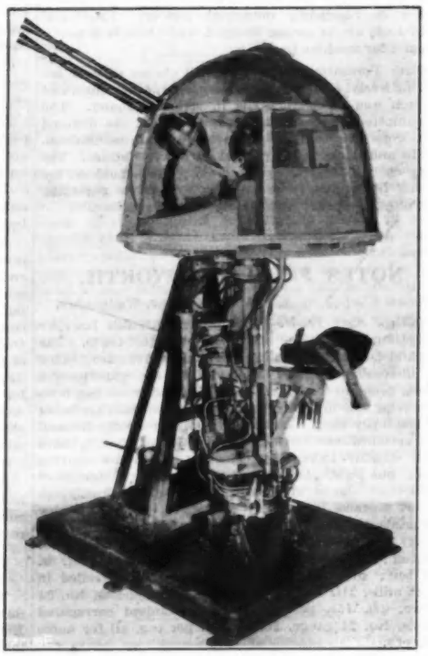


FIG. 5. TWIN-GUN TURRET.

COKE RESEARCH IN THE MIDLAND AREA.

THE objects of the Midland Coke Research Committee are to study and evaluate the properties and qualities of coke; to standardise methods of assessing the properties of the material, and to determine means for improving its qualities. The properties of coke, regarding its use in the blast furnace and for other metallurgical purposes, have been the main concern of the Committee since its formation in 1926, but the use of the fuel for other special applications and for domestic purposes is also receiving attention. The experimental work of the Committee is carried out in the Department of Fuel Technology of the University of Sheffield, St. George's-square, Sheffield, 1, and at neighbouring coke-oven and blast-furnace plants. The Committee is financed by funds subscribed by the producers of oven coke operating in the Midland area, supplemented by a grant from the Department of Scientific and Industrial Research, this grant being administered by the Industrial Research Council of the British Iron and Steel Federation. It is stated, however, in the Committee's annual report of progress during 1940, which has just been issued, that the Committee has now become a financially independent organisation, though continuing to be provided by the University with free accommodation, heating, lighting and other services. Dr. R. A. Mott, F.I.C., hitherto Secretary to the Committee, has been appointed its Director of Research, and the University has made him lecturer in coking processes in the Department of Fuel Technology.

The report shows that an interesting investigation on the influence of coke size in the working of a blast furnace has been conducted by the Committee during the year under review. An analysis has been made of the operating records of the furnace, covering a period of 15 months, during which two grades of coke were used, one of them containing a considerably higher proportion of smaller sizes. Monthly records indicated that an increased slag production and a higher coke consumption, per ton of iron, resulted from the use of coke containing the higher proportion of smaller sizes. A comparison of the actual slag production per week, with the theoretical production per week—calculated from the constituents present—suggested that periods of accumulation of slag-forming materials occur, followed by periods during which these accumulations are released. During periods of release the working of the furnace becomes disorganised with a consequent lower output and higher fuel consumption.

Further series of large-scale tests have been carried out to confirm the conclusion, obtained from experimental-oven tests, that, if coke dust is ground sufficiently finely, blending it with coking coal increases the shatter index of the coke, but does not affect its Cochrane abrasion index. In the tests, two coals, A and B, were coked as such and also when blended with 4 per cent. of coke dust. Coal A yielded a coke having a 1½-in. shatter index of 71·6, and coal B a coke of index 77·2, but, after blending with 4 per cent. of coke dust the shatter index of the coke produced with coal A became 77·1 and that with coal B, 80·7. The ¼-in. abrasion index of all four cokes remained stationary in the vicinity of 77.

The Ganister coal of South and West Yorkshire is a good coking coal, but its high sulphur content, which is of the order of 4 per cent., has so far precluded its use for the production of coke. Ordinary methods of washing fail to reduce the sulphur appreciably. Furthermore, float and sink tests conducted on coal crushed to different maximum sizes have shown that crushing as fine as to pass the 200 I.M.M. sieve fails to release all the pyrites, which are the chief source of the high sulphur. On the other hand, crushing to 0·1 in. frees 50 per cent. of the pyritic sulphur. To avoid difficulties resulting from the handling of very fine coal, it has been concluded that crushing the coal to 0·1 in., removing all dust passing a 60-mesh sieve, and washing the oversize in a trough washer, would reduce the sulphur content of the coal to 3·0 per cent. From this coal a coke containing 2·4 per cent. of sulphur could be produced and it is felt that, in many circumstances, the high physical quality of this coke would compensate for its high sulphur content. A co-operative research carried out in collaboration with the South Yorkshire Survey Committee of the Fuel Research Board has shown that coke, made in the experimental oven, from finely-crushed Parkgate "hards" (mainly consisting of durain) had a 1½-in. shatter index of 90·7, a sulphur content of 0·66 per cent., and a content of high melting point of 4·5 per cent.

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Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

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TELEPHONE NUMBER—TEMPLE BAR 3663 (2 lines).

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CONTENTS.

	PAGE
The Claytor Hydro-Electric Power Plant (*Illus.*)	441
Literature.—Fourier Series and Boundary Value Problems	442
Suffolk Post Mills (*Illus.*)	443
60-kVA Welding Machine for Projecting Parts (*Illus.*)	446
The "Bristol" Hydraulically-Operated Aeroplane Gun Turret (*Illus.*)	446
Universally-Adjustable Pattern-Making Machine (*Illus.*)	447
Directorate of Industrial Electrical Equipment Area Organisation	448
Institution Elections	448
Books Received	448
Personal	448
Notes from the South-West	448
Notes from South Yorkshire	449
Notes from the North	449
Notes from Cleveland and the Northern Counties	449
Notices of Meetings	449
Coke Research in the Midland Area	450
Efficiency in Tractor Ploughing	451
Electrical Bushings	452
Notes	453
The Iron and Steel Institute	454
Letter to the Editor.—Paper and Munitions	455
London and North-Eastern Railway Locomotives for Overseas (*Illus.*)	455
Modern Technique in Tractor Ploughing (*Illus.*)	456
Labour Notes	457
A Century of Tunnelling (*Illus.*)	457
"ENGINEERING" Patent Record (*Illus.*)	460

ENGINEERING

FRIDAY, DECEMBER 5, 1941.

VOL. 152. No. 3960.

EFFICIENCY IN TRACTOR PLOUGHING.

LAST week the Minister of Agriculture reviewed the progress of the national food production effort. Since the war began, the area of land under crops has been increased by about 45 per cent. New arable land has been added, both by straightforward ploughing-up of grassland and by the reclamation of derelict areas. The output of cereal products this year will be at least half as much again as in peace time, while the production of potatoes will be nearly doubled. But, as the Minister pointed out, limitations of labour and machinery will tend to prevent further increases of arable land, and efforts in the future will have to be directed mainly to consolidating the gains already made. Some new land will be broken up, no doubt, and more reclamation schemes undertaken, but, at the same time, some of the land already broken will be laid down to grass.

The machinery position was reviewed in our issue of October 10. It was pointed out that, although there are now more than twice as many tractors as in September, 1939, there is no slackening in the farmers' demands for more machines of every type. Indeed, it is safe to say that, at the present moment, most tractor agents have more unfilled orders on their books than ever before. Nor is it difficult to see why this should be so, for, taking into account nearly a million farm horses, whose numbers can hardly have changed appreciably during the past two years, it is doubtful whether the total motive power of British agriculture has increased by more than 25 per cent. since the war began. Over the same period, the demand for farm power has increased by something nearer 50 per cent. It is true that this estimate is based on a simple comparison of present and pre-war arable acreages, without regard to the power used in grassland farming; but it also makes no allowance for the greater intensity of present-day arable cultivation, the greater proportion of cropped land, and the smaller proportion of temporary leys.

In point of fact, however, the above argument is less sound than it may appear, for it takes no account of efficiency of utilisation. What an increased acreage requires is not actually more power, but more work; and, in theory at any rate, it may be possible to attain this by making fuller and more effective use of the power already available. It is a matter of common knowledge that very few pre-war farm machines were used to full capacity, and, although most tractors do more work to-day than ever before, there is no reason to suppose that a limit has yet been reached. The general question of more efficient utilisation of farm machinery is a very difficult one, depending as it does on the size and circumstances of individual farms, on the vagaries of the weather, and on the ability and experience of the operator. But in one direction, at any rate, something can be done to increase output: whenever a tractor is at work in any of the heavier operations it can be provided with an implement large enough to absorb its full power.

This apparently simple matter is arousing much interest, and much controversy, in agricultural circles at the moment, especially in connection with ploughing. It is claimed, on the one hand, that thousands of tractors up and down the country are being operated with two-furrow ploughs, when they ought to be making fuller use of their power, and giving a correspondingly greater output, by ploughing three—or, in some cases, even four—furrows at a time. It is objected, on the other hand, either that the tractors in question are not capable of ploughing more than two furrows, day in and day out, without detriment to themselves; or, alternatively, that the advocates of wider ploughs have no experience of heavy land. These objections, moreover, are difficult to counter without recourse to engineering terms—horse-power, drawbar pull, soil resistance, and so on—which farmers in general do not readily understand, and so regard with some suspicion. In the circumstances, the only effective answer is practical demonstration; one example of what can be done in this direction is described on page 456 of this issue. This particular demonstration was arranged by the Hampshire War Committee, and was attended by some hundreds of local farmers. They saw one Fordson tractor doing good work with a four-furrow plough, and another pulling a three-furrow plough, with a press behind. Dynamometer measurements showed that the land was not unduly light, but that neither tractor was being overloaded. What will count for most, however, in the mind of the average farmer who saw it, is the fact that a Fordson was actually ploughing four furrows under conditions in which his own tractor would have been quite content with two.

It happens that the engineering facts relating to this particular question can be set out more precisely than is generally the case with agricultural problems. With hardly any exceptions, all the tractor models in use have been officially tested, either in this country or in the United States, and detailed test reports giving both the maximum and the rated drawbar power are available. It is a simple matter to calculate the drawbar pull that can be transmitted under normal conditions in the particular gear, and with the particular size of driving wheel, that is to be used for any job of ploughing. Moreover, within close limits, the draught of the plough will be proportional to the cross-sectional area of the furrows that are being cut. Ploughing resistance, as the draught of a typical plough divided by the cross-section of its furrows is called, varies widely from one field to another, and even from one day to another in the same field; but the limits between which it varies are known, and standards for average heavy and light land have been laid down for use in the Tractor Testing Scheme of the Royal Agricultural Society of England. In carrying this discussion a stage farther, there will be no great loss of generality in speaking particularly of Fordson tractors, because something over 80 per cent. of all the wheel tractors on British farms are of this type.

There are two models of the Fordson tractor, the "Red Spot" and the "Green Spot," differing only in the slightly higher gearing of the latter, and both have been tested fairly recently under the R.A.S.E. scheme. The engine is of the same type in each case, with four cylinders arranged vertically in line. The cylinder bore is 4½ in. and the stroke 5 in., and the nominal governed speed at full load is 1,100 r.p.m. The engine starts on petrol and runs on vaporising oil. The drive is through a foot-operated main clutch (also operating the transmission brake) to a gearbox with three forward

speeds and one reverse; and thence to the rear wheels, which are 42 in. in diameter and 9 in. wide. They are normally fitted with 4½-in. spade lugs, but the tractors are also supplied with rubber tyres, with or without water ballast. The machines used in the demonstration had wheels of the last-mentioned type. The standard "Green Spot" model has gear ratios giving forward speeds of 2·04, 3·09 and 4·31 miles an hour, with a reverse speed of 1·75 miles an hour. The "Red Spot" tractor has forward speeds of 1·61, 2·45 and 4·31 miles an hour, and a speed in reverse of 1·38 miles an hour.

The official tests by the Royal Agricultural Society were carried out in March and October, 1940. The full series were five in number in each case, the first four being determinations of the maximum power developed in ploughing, subject to certain specified conditions; the maximum drawbar pull; the power developed in cultivating rough loose fallow; and the dilution of the lubricating oil. The last-mentioned test was not carried out, as the trials were run on war-time "pool" fuel instead of the standard commercial grade; but this point is not material to the present purpose. The fifth test consisted of eight-hours' ploughing tests, first on heavy land (permanent pasture on gault clay) and then on light land (barley stubble on light-medium loam, overlying gravel).

The only results that are relevant to the present question are those of these eight-hours' ploughing tests on heavy and light land. The "Red Spot" model used a three-furrow plough, cutting furrows rather over 11 in. wide and 5 in. deep on heavy land with a ploughing resistance of just under 13 lb. per square inch, working in second gear at a speed of 3¼ miles per hour. The "Green Spot" model pulled a similar plough and achieved a comparable performance in all respects. On the light land, both machines pulled a four-furrow plough without being fully loaded. Land of 13 lb. per square inch resistance is certainly heavier than most—in fact, it is understood that heavier land has been encountered on only a very few occasions. There would seem, therefore, to be no doubt about the general argument that, on most of the land now in cultivation, a Fordson ought to pull at least a three-furrow plough. Indeed, any farmer who felt that the circumstances of the test would not apply to his own fields could very easily carry out a special test for himself. He need only set in his plough for a round or two to whatever depth was necessary to put the tractor in difficulties. By a simple proportion sum, he could then work out the width of plough that would load his tractor fully at his normal depth of working.

But the facts remain that most Fordsons do use two-furrow ploughs, with a consequent and regrettable loss of time, fuel, and man-power; and that a great many more demonstrations will be needed before matters are improved. One reason is the mistaken idea that there is something to be gained by working a tractor at less than its full normal output. Actually, there is nothing at all to be gained; and, with a paraffin engine, the most probable result is that the tractor will wear out more quickly than if it had been fully loaded. Another reason is that most farmers think solely in terms of the heaviest corner of their land. Because some of their land is heavier than the rest, or because some work must occasionally be done when conditions are unfavourable, they will use a two-furrow plough throughout, and suffer an unnecessary loss of output and efficiency in the greater part of their work. They even forget that most ploughs are readily convertible from two to three furrows, or vice versa.

The full problem, of course, affects other operations besides ploughing. The most successful farmer of the future will have all his implements "teamed" to use his motive power to the best advantage; and the most successful manufacturer will be the one who designs his implements with this in mind. At the moment, however, the ploughing aspect alone is important enough—it has been estimated that proper loading would increase the nation's present ploughing strength by up to 40 per cent. without making a single extra demand on men, materials or shipping.

ELECTRICAL BUSHINGS.

THE design of terminal bushings is affected by the combination of mechanical and electrical problems met with in many spheres of electrical practice. Such bushings are required for circuit breakers and transformers, or for making connection to outdoor conductors through the walls or roofs of power stations or substations. When practical applications were confined to moderate voltages and small powers, solid porcelain bushes met the electrical and mechanical conditions reasonably satisfactorily, but the powers which are now handled, at voltages reaching the 132,000 mark, have altered the whole question of the problem of design. Most outdoor bushings now used have an insulating shell protecting the outer end from weather conditions; in some cases this shell extends through the fixing flange and surrounds the bottom end of the conductor. The insulating material, solid or fluid, interposed between the earthed flange and the conductor, may or may not include the porcelain protective shell. In general, the insulating material constituting the bushing is arranged so as to modify the electrical stress distribution. With a single insulating medium, the stress varies inversely as the radius from the conductor, so that the maximum value is at the inside of the bushing. If this is of porcelain or glass, there will be a thin air layer between the dielectric and the live conductor. With high voltages, this layer would be subjected to excessive stress and, as the air is stagnant, progressive ionisation may occur; these conditions may lead to internal flashover. One method of dealing with them is to metallise the inside of the hole through the porcelain, thus relieving the air layer from stress.

Among the various methods which have been used to ensure contact between the dielectric and the conductor, and so eliminate the air space, oil and plastic-solid fillings have been employed. According to Mr. W. A. Cook, this procedure may be used up to 33,000 volts, as compared with 11,000 volts for a solid porcelain insulator. Mr. Cook dealt with this subject in a recent paper entitled "Outdoor Bushings—their Construction, Testing and Standardisation," presented to the Institution of Electrical Engineers. The use of a fluid or solid filling in this way will not eliminate the occurrence of the highest electrical stress at the conductor surface, although it may reduce the stress across the outer porcelain shell. It is this condition which limits the voltage for which this type of construction is suitable. The plastic solids available will not stand very high stresses and although oil is better in this respect, impurities tend to align themselves in the field. This latter effect may be reduced by the use of cylindrical barriers. These may be made of Bakelised paper, pressboard or porcelain. Pressboard has the advantage of absorbing oil and so diminishing the stress owing to a resulting permittivity more nearly equal to that of the oil. This arrangement does not, however, reduce the maximum stress in the oil immediately surrounding the conductor, and may increase it. Instead of barriers, the conductor may be wrapped with paper, filling the space between it and the supporting flange, the wrapping being vacuum-impregnated with oil.

A form of construction which is mechanically independent of the porcelain shell, or the filling material, is obtained by wrapping the conductor with layers of Bakelised paper. A metal layer may be embedded in the material near the outside, and connected to earth. This transfers the heavy concentration of stress at the end of the supporting flange into the Bakelised paper, which is better able to withstand it than the surrounding oil or air. A similar metal layer on the inside, connected to the conductor, short-circuits any air between the conductor and the insulator. Above 11,000 volts further precautions are often necessary to avoid surface discharges, and metal layers are introduced at frequent intervals throughout the insulation giving the well-known condenser bushing. This regulates the distribution of voltage along the surface and through the thickness of material, with the result that both the clearances and the diameter of the bushing may be reduced. A very uniform distribution of stress through the insulating material may be obtained in this way. Mr. Cook stated that at voltages above 132,000, oil cooling to dissipate losses is an advantage with bushings of this type, the arrangement taking the form of two condenser insulators in series, with an oil space between.

Assuming that they are not exposed to external mechanical forces, these various types of bushing are reasonable mechanical components. This condition applies in the case of transformers and, in general, of insulators carrying connections through walls. Circuit-breaker bushings, however, operate under very different conditions. Apart from mechanical stresses set up by the operation of the breaker, they are subjected to electromagnetic forces, particularly under conditions of short-circuit. They must be capable of resisting an upward force along the centre line, tending to push them through the flange; a force at the bottom end, at right angles to the centre line, tending to bend the lower part which projects below the flange; and a torque about the axis. In cases in which these forces are small, or moderate, they may be taken by the porcelain shell extending below the flange. Porcelain has a tensile strength of about 4,500 lb. per square inch, as compared with a figure of 14,000 lb. for the Bakelised paper shell. The impact strength of the latter is also much greater. Although the carrying of the mechanical forces by the porcelain is a convenient arrangement, these figures illustrate why it can be adopted only for breakers of small capacity, unless the shell is made inconveniently large.

The shear resistance between the laminations of a Bakelised paper bushing is only about 600 lb. per square inch, such a bushing may nevertheless be successfully used to carry the mechanical stresses. Although the whole of the applied forces have to be transmitted as shear forces through the body of the bushing, the actual area of laminations is so great that mechanical performance superior to that of a porcelain shell is secured. The arrangement has been used successfully on breakers operating at 132,000 volts. The success of this arrangement depends to a considerable extent on the way the forces are applied to the Bakelised paper, and the shrouding of the lower end of the bushing by means of a metal socket is a considerable advantage. Failure of a Bakelised-paper bushing under mechanical stress may not take the form of actual fracture; distortion sufficient to alter its electrical characteristics is sufficient to render it useless. For very high capacity breakers, additional mechanical strength is frequently provided. One method is to provide a separate Bakelised-paper shell outside and independent from the condenser bushing. This outer shell acts as a mechanical unit only, the electrical stresses being taken by the bushing. The upper end of the outer shell is securely fixed in the supporting flange on the circuit-breaker cover, the lower end being connected to the conductor, where it enters the condenser bushing, by a metal flange. The insulating properties of the Bakelised outer shell allow of its insertion in this way directly across the full circuit voltage.

The design of a bushing may have to be modified if a straight-through current transformer has to be provided on the main connection leaving the circuit breaker or transformer. In general, circuit-breaker bushings are long enough to accommodate such a series transformer between the tank top and the oil level, but power transformers will frequently require bushings longer than normal. If the purpose of the series transformer is to operate a protective system it is important that it should be arranged so that it will be protected in case of breakdown of the circuit breaker or power transformer. If it is mounted on the centre part of the bushing, as can frequently be arranged, and an earthed screen is provided between the bushing insulation and the transformer, the effect of a breakdown of the bushing will probably not extend to the transformer quickly enough to prevent the relays from operating. An alternative way of mounting a series transformer is to sling it from the bushing flange below the top plate of the circuit breaker. In this case it has to be of larger diameter than a transformer carried directly on the bushing, but has the advantage of being easily accessible.

NOTES.

THE NEW MAN-POWER PROPOSALS.

In the House of Commons, on Tuesday, December 2, the Prime Minister outlined the Government proposals for a more extensive mobilisation of the nation's resources in man-power and woman-power, for the purpose of staffing the new war factories and releasing a larger number of men, already in the Forces, for combatant duties. The age for compulsory military service for men will be raised from the present limit of 41 to 50; not all are likely to be taken into the uniformed Services, but some may be required to transfer to work more directly concerned with the war than is their previous work. Block reservations of particular occupations is to be superseded by a system of individual deferment, and the present ages of reservation, where such exist, will be raised by one-year stages at intervals of a month. The age at which liability for military service commences will be reduced to 18½. Unmarried women between 20 and 30 are to be compulsorily liable to service in the uniformed auxiliary Services (which, in practice, will mean the A.T.S.), in civil defence, or in industrial work. Boys and girls between 16 and 18 will be registered, and will be encouraged to join the appropriate youth organisation, through which they can obtain training to fit them for national service when they reach the age of conscription. Explaining the proposals, Mr. Churchill said that the crisis of equipment was largely over, but that 1942 would be dominated by the crisis of man-power and woman-power. The great supply plants were largely finished, but must be fully staffed. The powerful mobile Army that had been created must be maintained; it was necessary to provide for the expansion of the Royal Air Force in 1942, and the still greater expansion of 1943; and there was the continuous growth of the Royal Navy, as the great number of new warships came steadily into service. In addition, substantial supplies of tanks, aeroplanes and other weapons were required for Russia, and to take the place of the American supplies, originally intended for Britain, which were being diverted to Russia. Of the population of Great Britain—about 46,750,000—there were about 33,250,000 men and women between the ages of 14 and 65. The munitions industries had made more rapid progress in the first two years of this war than in the four years of the last war; at the present time, a million more men were engaged on munitions than there were at the end of the last war. Men now working on munitions would become de-reserved, and those who were not granted deferment would be recognised as being available for transfer to work of higher priority. Men not in the war industries, and not granted deferment, would be called up to the Forces, in which those over 41 would be posted to the less active duties, to release younger men.

PAYMENT BY RESULTS IN THE BUILDING INDUSTRY.

A joint memorandum issued by the Minister of Labour and National Service and the Minister of Works and Buildings states that payment by results was introduced at the beginning of July, by Government decision, for certain operations on building and civil engineering works scheduled under the Essential Work (Building and Civil Engineering) Order, and considerable experience has now been gained of its operation. Notable increases in output have been attained in many cases, but it has been shown that the scope and usefulness of the scheme have been diminished because it has been confined to civil engineering and bricklaying. The Government is reluctant to intervene in the matter of rates of payment, but, taking the most favourable view of the existing position, there is bound, for various reasons, to be prolonged delay before the two sides of the building industry can reach agreement. As it is essential that no further time should be lost, the Government has decided to extend the principle of payment by results to the maximum extent on all scheduled sites for factories, hostels, transport and port works, aerodromes and other vital war installations. Accordingly, machine excavation, excavation by hand, concrete mixing and placing, and all recognised civil engineering operations, pipe laying, brickwork, carpentry and joinery, hutting, plastering, and painting and glazing will now be subject to payment by results. Additional schedules covering other operations will be issued later. The new scheme applies only to sites scheduled under the Essential Work (Building and Civil Engineering) Order. On these sites, no departures from the principle of the scheme and no unauthorised methods of "bonusing" will be permitted, whether agreement is reached with the operatives on the site or not. On the other hand, builders and contractors operating on sites not scheduled under the Essential Work Order are required, as a condition of holding their certificate of registration under Defence Regulation 56 AB, to observe the terms and conditions of employment fixed by joint agreement in the industry, or by arbitration. It will, therefore, not be open to contractors on non-scheduled sites to operate bonus schemes, unless they are in accordance with the terms and conditions of the industry. The Ministry of Works state that the executives of the unions in the National Federation of Building Trades Operatives have agreed to play their part in guiding policy on the application of payment by results. This decision signifies that the Ministry can now appoint an official panel of both sides to give advice on all matters arising out of the administration and working of the scheme.

THE EFFICIENCY OF SMALL BOILER PLANTS.

The thermal efficiency of boilers in small plants is often the last operating condition to be considered if, indeed, it is considered at all by those responsible for running such plants. Mr. David Brownlie, in a series of articles published in ENGINEERING some 20 years ago, rated the net working efficiency of plants burning up to 20 tons a week at about 54 per cent. Since that date, it is true, efforts have been made to improve the firing conditions of plants not under trained supervision by the publication of various handbooks written primarily for the fireman, but there is still much room for improvement; how much, can be estimated from the fact that an aggregate of some 45,000,000 tons of coal per annum is consumed in small steam-raising plants. Apart from personal benefit to the owners of this class of plant, an improvement in efficiency would contribute to the national effort, since a great part of the consumption is at present concerned with war material production. The British Coal Utilisation Research Association are undertaking a research into the firing of small and medium-sized boilers, with the object of widening the range of fuels which can be satisfactorily burned in these boilers and to determine the factors which control the maximum burning rate obtainable with any given type of coal and method of firing. With adequate co-operation, this movement should be productive of much improvement. The work is sponsored by the Association of Shell Boiler Makers and by the Combustion Appliance Makers Association (Solid Fuel), and the general lines of the research follow those laid down by a Joint Committee on which some of the Government Departments concerned in the use of steam-raising plant were represented, together with manufacturers of boilers and firing equipment. The research should give considerable assistance to the Fuel Efficiency Campaign, recently launched by the Mines Department. All those interested in the research are invited to communicate with the secretary of the Research Committee, Mr. H. G. Crone, at the British Coal Utilisation Research Association's Experimental Station, Rickett-street, Fulham, London, S.W.6.

WROUGHT LIGHT ALLOYS DEVELOPMENT ASSOCIATION.

The main policy adopted by the Wrought Light Alloys Development Association, at the present time, is the dissemination of all the available information on the physical, mechanical and working properties of the strong aluminium alloys, in order to assist the war effort to the fullest possible extent. Difficulties encountered in the manipulation, heat treatment and finishing of some of these alloys, particularly in works in which they have not been employed previously, are usually due to lack of experience or to the scarcity of published information on the technique required. Moreover, it is not always possible at present for suppliers of material to give their clients the detailed attention they would desire. The Association therefore intends to place its services at the disposal of any fabricators or users of aluminium alloys having problems which cannot be solved in their own works. The Association was incorporated as a company, limited by guarantee, early in the present year, and comprises the principal makers of the wrought light alloys in this country. Dr. E. G. West, B.Sc., who has had a varied experience in light-alloy metallurgy, has recently taken up the post of manager, with an office at 34, New-street, West Bromwich. An advisory service bureau has now been set up to deal with technical problems, especially those which occur in the various fabrication operations. Backed by the experience of the producers and of many of the largest users of the alloys, it is stated that this consultant service is able to provide reliable information to any user, however small. Inquiries, which should be accompanied by samples whenever possible, must include full details regarding the material, the operations concerned, any remedial measures which have been tried, and other information considered to be relevant. At the conclusion of hostilities the Association will continue its advisory service and so assist industry to change over to civil requirements. In addition to keeping in touch with all progress and developments and collecting and collating information, the Association will sponsor research schemes from time to time, with a view to extending knowledge on the aluminium alloys and investigating new applications.

AWARDS TO SWEDISH ENGINEERS.

At its 22nd annual meeting, held at the end of October, the Royal Swedish Academy for Engineering Research conferred awards upon a number of Swedish engineers for outstanding technical and scientific achievements. The Academy's large Gold Medal was awarded to Mr. Hemming Johansson for his work in developing telephone technique and in promoting the Swedish telephone industry. Mr. Johansson was appointed technical manager of the Swedish Ericsson Company in 1898 and continued in this capacity for 37 years; he was also chairman of the Company from 1909 to 1925. It was during his period of office that the firm's automatic telephone system was developed and introduced into Sweden, and in a number of other countries. Mr. Johansson is the sixth Swede to have received the Academy's large Gold Medal. Ordinary Gold Medals of the Academy were awarded to Mr. Carl Montelius and to Messrs. Georg Schönander and Sven Ledin. Mr. Montelius is the originator of the Imo high-speed high-pressure pump, and Messrs. Schönander and Ledin have conducted research work which has resulted in making Sweden self-supporting in the matter of the production of X-ray tubes of high quality. The De Laval Silver Medal was awarded to Mr. E. V. Nyberg, of the Swedish Post Office, for his work in developing automatic and semi-automatic machines for the postal service. He has been responsible for an automatic letter-conveyor, an automatic stamp-selling machine, a letter-stamping machine, and a printing press for letter-cards. The latter prints, perforates, gums, cuts and folds the cards, delivering them ready for issue. The remaining award of the Academy was that of its Medal of Appreciation. This was presented to Mr. Emil Sieurin for his work, extending over many years, in the development of home-produced motor fuels.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—The Council of the Institution of Automobile Engineers has awarded the Crompton Medal, for the session 1940-41, to Dr. H. E. Merritt, for his paper, "The Scope of Gear Research." The second Graduates' Prize, of the value of 8*l.*, has been awarded to Mr. C. D. Carmichael, B.Sc., of the London Graduates' Branch, for his paper, "Aero-Engine Cooling." The first Graduates' Prize has not been awarded. Under the will of the late Sir Edward Manville, and consequent upon the death of Lady Manville in August, the sum of 5,000*l.* has been left to the Institution for the foundation of exhibitions or scholarships in automobile engineering. The Council has appointed a sub-committee to consider the precise form in which the bequest shall be applied.

THE IRON AND STEEL INSTITUTE.

THE annual autumn meeting of the Iron and Steel Institute was held at the offices of the Institute, 4, Grosvenor-gardens, London, S.W.1, on the afternoon of Tuesday, November 25. The President, Mr. John Craig, C.B.E., occupied the chair. The minutes of the previous meeting having been dealt with, the secretary was called upon to read a list of the names of officers who were due to retire, in rotation, at the next annual meeting. This list comprised three vice-presidents, namely, Dr. W. H. Hatfield, F.R.S., Sir William Larke, K.B.E., and Dr. C. H. Desch, F.R.S., and five members of the Council, namely, Mr. A. B. Winder, Mr. W. J. Brooke, Mr. E. J. Fox, Mr. J. Sinclair Kerr, and Dr. T. Swindon. The secretary also stated that the Carnegie Scholarship held by Dr. M. Balicki would be continued, at the rate of 100*l.*, for 1942, for a research being conducted under Dr. Edwards at Swansea. The President then announced that Mr. James Henderson had been unanimously nominated by the Council to be the next President of the Institute and that he would be formally elected at the annual meeting in 1942. Mr. Craig further announced that Dr. A. McCance had been nominated by the Council to be a vice-president.

On being called upon to speak, Dr. W. Wrazej, a Polish member, who was in military uniform, stated that all Polish technicians stood firm in the ranks of their British colleagues in making every effort to secure victory. Having in mind the concentration of endeavour necessary to attain the common goal, an organisation called the Institute of Technical Research had been created in the General Staff of the Polish Army. This Institute comprised the ablest Polish technicians and represented all branches of science, including metallurgy, and its members were collaborating in British industry. He knew from experience that much good work was being done in this way and he hoped that the future would witness still closer co-operation. In thanking Dr. Wrazej for his remarks, the President reciprocated the sentiments expressed and added that his own firm was being greatly helped by the knowledge and experience of some Polish technical men who had joined the staff in recent months. They were rendering excellent service which was highly appreciated, not only by the directors of the firm but by many of the employees who had been impressed by the efficiency and enthusiasm of the Polish technicians. In a final comment before proceeding with the papers on the agenda, Mr. Craig stated that under the inspiring leadership of Dr. Hatfield, the Research Committees of the Institute were fully engaged on work of the highest national importance. In other directions the Institute had not been able to function as completely as in normal times, but the Council was highly gratified at the substantial addition that was being made to the membership. There had been a large accession of members from America, and, in fact, the American membership now stood higher than ever before. Thus, although the Institute had lost members from elsewhere, it had gained them in a country with which we now had, and would continue to have, the closest co-operation.

MANGANESE AND SEGREGATION.

"Apparent Relations between Manganese and Segregation in Steel Ingots," by Mr. J. H. Whiteley, was the first contribution to be considered at the meeting. In presenting it, the author stated that, distributed though the many reports of the Committee on the Heterogeneity of Steel Ingots, were to be found descriptions of about 70 steel ingots ranging from ½ ton to 172 tons in weight. In plain carbon steels, which were alone dealt with, there were four segregating elements, namely, carbon, phosphorus, sulphur and manganese and, of these the first three were fairly consistent in their behaviour, but that of manganese was unmistakably erratic. In some ingots the increment was quite large, while in others it was comparatively slight, even when the segregation was obviously pronounced. As a result of the examination of all the data, four tentative conclusions had been reached. In the first place, the ratio of the manganese increase to that of the sulphur was, as a rule, higher in sound than in unsound ingots. Secondly, carbon, phosphorus and sulphur could all carry some excess of manganese in segregating, the inference being drawn that all three elements existed largely as compounds of iron and manganese in the liquid steel near the freezing point. Thirdly, in sound ingots a linear relationship appeared to obtain between the ratio of the increment of manganese to the total increment of carbon, phosphorus and sulphur, and the ratio of manganese to these elements, at the position at the base of the cavity in the ingot head. In the fourth place, segregation was diminished as the ratio of the manganese to the carbon, phosphorus and sulphur in the steel was increased.

Dr. W. H. Hatfield, F.R.S., who opened the discussion, said that this was the kind of contribution that the Heterogeneity Committee welcomed. During the past 18 years the Committee had cut up ingots to the value of some 100,000*l.* in their researches and this had been well worth while, for it had enabled ingots to be examined with a greater degree of exactitude than would otherwise have been possible. It was necessary for many workers to explore the information which the committee had accumulated and he suggested that the Council might offer Carnegie Scholarships to young men sufficiently interested in this intricate subject. Many members of the Committee were so fully engaged on current problems that they had not time adequately to consider the data. The Committee had been at work for 18 years, but he felt that it would take another 80 years before the problem would approach anything like the solution which was essential unless some concentrated efforts were made along the lines of the present paper. The next speaker, Dr. S. A. Main, stated that the real difficulty, even when the best possible figures were available, was to draw conclusions. He did not think that the author had quite made his point that the metalloids were partly combined with the manganese in the steel. The author evidently was relying on the relationships being exact, but they were not exact; they varied even inside the same ingot. There was no direct fixed proportionality between the elements; consequently a complex was more likely to be present than a chemical compound. The last speaker, Dr. C. H. Desch, F.R.S., stated that a good deal of oxygen was present in some of the ingots and this might account for the peculiar ratio of manganese to the other elements found in some instances. Mr. Whiteley intimated that he would reply in writing.

SPECTROGRAPHIC ANALYSIS OF SEGREGATES.

The second paper taken was entitled "The Application of Spectrographic Methods to the Analysis of Segregates." The authors were Mr. F. G. Barker, Dr. J. Convey and Mr. J. H. Oldfield. This contribution to the proceedings will be found on page 298, *ante*.

Mr. E. F. Deblow, in opening the discussion, stated that if a condensing lens were placed between the light source and the slit, more light should be provided. This would also help from the point of view of preventing so much scattering of the light and avoiding inaccuracies. The authors had not mentioned how long the electrode lasted, which was an important point in determining how much the cross-sectional area of the electrode varied over a given time. The next speaker, Dr. L. Frommer, said that his firm had tackled the problem of the analysis of segregates from a different angle. His method had been to scrape small particles in order to remove them bodily and to subject them to spectrographic analysis. Graphite electrodes were employed, the lower one being cored. The specimens, which might weigh anything between 0·10 mg. to 10 mg., were placed inside the core of the lower electrode, which was made the anode. It had been found that the results were accurate within 10 per cent., which was quite good on specimens of such small size. Unfortunately, his present equipment limited the size of the specimen; it could not be smaller than 0·10 mg., but he saw no reason why the method should not be applied to specimens weighing, say, 0·01 mg. Dr. D. A. Oliver, who spoke next, said that the illustrations showed convincingly that it was possible to get three or four determinations across the segregate as well as along the line of its length.

Mr. J. H. Whiteley said that the three elements most concerned with segregation, namely, carbon, phosphorus and sulphur, could not be determined by this method. This was unfortunate, but perhaps, in time, the authors would find a way of dealing with them. It was stated in the paper that the elements which segregated most were manganese and molybdenum, and, with regard to manganese, this was attributed to the effect of manganese sulphide. With regard to the molybdenum it was well known that if a steel containing molybdenum in quantity were dissolved in hydrochloric acid, the whole of the sulphur content was not released, suggesting the presence of a sulphide of molybdenum. The next speaker, Mr. D. M. Smith, stated that the results recorded were convincing and he felt sure that this method could be employed to identify the distribution of impurities in coarser crystal structures in non-ferrous metals. An important problem successfully solved by the authors was the influence on the analyses of the halo of the crater. Mr. E. H. S. Van Someren, who closed the discussion, asked the authors if they had found it possible to facilitate the localisation of the spark by an etching or staining process which produced selective oxidation of one or other of the constituents of the specimen.

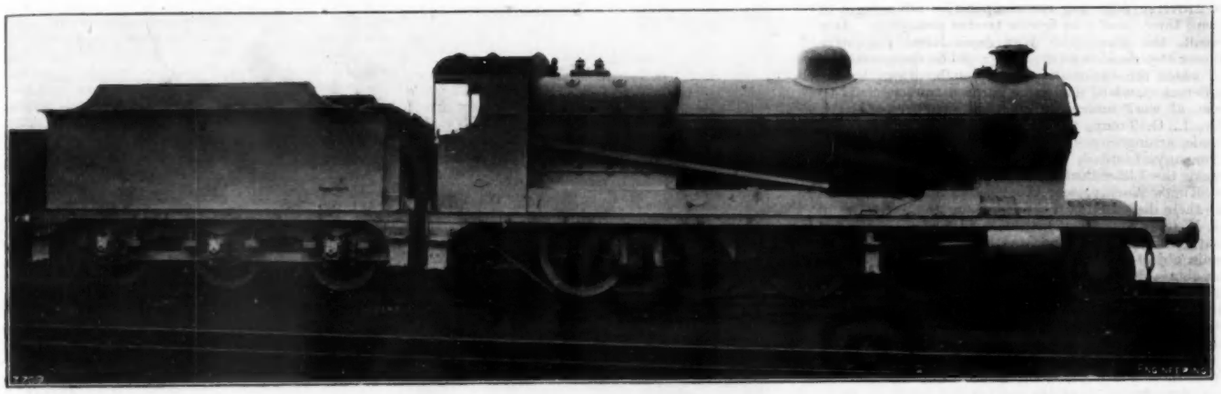
In a brief reply, Dr. Convey agreed that the use of a lens in the system might improve matters in the manner suggested by Mr. Deblow. As, however, the results were reproducible, this was not really necessary. The answers to many of the other questions would be found in a second paper to be published at a later date; since the present contribution had been written what might be termed the real results had been obtained. With regard to the time the electrode lasted, it could be said that an electrode could be run continuously for nine minutes without altering the length to any great extent; after that, the electrode "lost its point." In reply to Dr. Frommer, the information wanted was the variation of the composition within the segregate and he was convinced that the sensitivity obtained by the method described was higher than that obtained hitherto by other workers. Since the paper had been written, some work had been done on carbon. Phosphorus and sulphur were a little more difficult—particularly sulphur; these two elements required a great deal of excitation. No work had been done so far on the localisation of the spark by a staining process, as proposed by Mr. Van Someren, but it was a very good suggestion.

LADLE COOLING OF LIQUID STEEL.

The third paper dealt with was by Mr. T. Land and was entitled "The Ladle Cooling of Liquid Steel." The author stated that the development of the Schofield-Grace method of liquid-steel temperature measurement* had made possible a very accurate control of temperature in the melting furnace. From the foundry point of view, it had become important to know what fall in temperature was to be expected between tapping and casting, and the present paper explained how this might be calculated. A simple experiment with a model showed how the metal in the ladle cooled through a relatively thin layer of metal passing down the vertical walls of the refractory lining and forming a reservoir of cool metal at the bottom of the ladle. The amount of heat extracted by the ladle refractories could be calculated, and particular attention was drawn to the effect of preheating the ladle. It was deduced that, to obtain efficient preheating, the preheating period must bear a definite relation to the time taken to tap and cast. The results of the investigations were presented in the form of a table which gave the drop in temperature for different sizes of ladle and different times of casting and tapping. The effect of varying the tapping temperature and the

* See ENGINEERING, vol. 147, page 545 (1939).

L.N.E.R. GOODS LOCOMOTIVES FOR FOREIGN SERVICE.



temperature to which the ladle was preheated could be allowed for by multiplying the figures in the table by a simple factor. A second table gave corrections which could be applied for different methods of casting and for the time that the metal was held in the ladle between tapping and casting.

In the course of the discussion, Dr. C. H. Desch F.R.S., said that it should now be possible in a steel foundry, with the aid of the immersion pyrometer, which the Heterogeneity Committee had done so much to develop, and the tables in the present paper to control the temperature in steel casting almost to perfection. The next speaker, Dr. R. J. Sarjant, expressed gratification that the author had given other workers in this field data which they could apply, although the tables furnished might not necessarily suit other peoples' practice. In a brief reply, Mr. Land agreed that certain points which had been noticed in his experiments did not necessarily occur under all conditions. Neither did he suggest that the results of the mathematical investigations in the paper were to be preferred to practical observation. His one object in publishing this work had been to suggest a method of correlating isolated observations and of providing a means of forecasting, with a fair measure of accuracy, what would happen under conditions other than those actually tried out.

ROOFS OF BASIC OPEN-HEARTH FURNACES.

The fourth contribution to the proceedings was a report by the Open-Hearth Refractories Joint Panel, working under the ægis of the Iron and Steel Industrial Research Council and the Council of the British Refractories Research Association. The report was entitled "A Co-operative Investigation of the Factors Influencing the Durability of the Roofs of Basic Open-Hearth Furnaces," and was in reality a series of papers on this subject. These papers concerned such matters as the manufacture of the roof bricks and their properties before use; the furnace—an 80-ton fixed unit of normal construction—and the pyrometer installation; the furnace campaign; the examination of samples taken from the roof at the end of the campaign; X-ray studies of the raw material and of used silica brick from the furnace roof; and the microstructure of used roof bricks. The report was formally presented to the meeting, but it was not introduced or discussed. Votes of thanks to all the authors of the various papers submitted brought the meeting to a conclusion.

WAR-DAMAGE INSURANCE OF YACHTS.—The Board of Trade informs us that, pending an amendment of the War Damage Act, 1941, provisional arrangements have been made for the insurance, against war damage, of private sea-going yachts which are laid up. The rate of premium for this insurance is that payable under the private chattels scheme and the payment of compensation will normally be deferred until after the war. Further information and proposal forms can be obtained from the Assistant Secretary, Insurance and Companies Department, Board of Trade, Romney House, Tufton-street, London, S.W.1.

LETTER TO THE EDITOR.

PAPER AND MUNITIONS.

TO THE EDITOR OF ENGINEERING.

SIR,—In the article entitled "Paper and Munitions," on page 432, of the issue of ENGINEERING for November 28, we are interested to see the reference to *The Midnight Watch* as a specific example of the wasteful use of paper by Government Departments. You may, in turn, be interested to know that upon receipt of copies of this absurd wall sheet, a few days ago, we accepted the invitation of its editor to communicate with him, though not exactly on the lines suggested. We pointed out that, in addition to Factory Act notices, which we are compelled to display, the notice-boards in these works are overcrowded with important notices of our own, many of which have to remain permanently on them, while in addition we receive from Government Departments a continual stream of new posters dealing with advice about air raids, fire-fighting, warnings about gas, safety-first, National Savings, digging for victory, increasing output, careless talk, helping Russia, etc., etc., for which we are at our wits' end to find space.

We remarked that *The Midnight Watch*, with nearly 3,000 words of text, was, in our opinion, unsuitable for use as a poster or wall sheet; it appeared indeed to be actually a kind of house magazine, and we pointed out that manufacturing firms are prohibited from publishing new productions of this type and have even been asked to suspend the production of existing house magazines. We also mentioned that the employees here are showing signs of becoming irritated by the continual poster exhortations, and frequently make comments, more forcible than polite, on the subject of the alleged shortage of paper in relation to the continual stream of fresh posters.

We believe that many others must share these views on the bad example set by Government Departments in this particular wasteful use of very large quantities of paper, and we hope that other periodicals, firms and individuals may be encouraged by your remarks to add their contribution to the volume of protest until it becomes so great that even a Government Department cannot ignore it.

Yours faithfully,
J. & E. HALL, LIMITED.
December 1, 1941. J. H. FILDES.

REGISTRATION OF BUILDERS.—Since the recent registration of over 104,000 firms engaged in building and civil engineering, an analysis has been in progress. Of the 86,580 firms engaged as general builders, building and civil engineering contractors, plumbers, joiners and carpenters, painters, roofers, plasterers, glaziers, demolition contractors and scaffolders, 79,985 have a maximum of 19 employees. Out of these, 64·16 per cent. are craftsmen and 35·84 labourers. Firms employing between 20 and 99 workpeople number 5,371, and 54·52 per cent. of their employees are craftsmen and 45·48 per cent. labourers. Firms having 100 employees and upwards number 1,224; 38·02 per cent. of these are craftsmen.

LONDON AND NORTH EASTERN RAILWAY LOCOMOTIVES FOR OVERSEAS.

IT has been announced that 92 London and North Eastern Railway 2-8-0 goods locomotives are to be sent overseas to assist in transporting necessary munitions to Russia. A typical engine of this class is shown in the accompanying illustration. The original locomotives of this design were built at the Gorton Works of the former Great Central Railway in 1911, and, by 1912, contracts had been placed with various British locomotive builders for a considerable number of the type, which was adopted as the standard for goods traffic in the South Yorkshire coalfields. During the war of 1914-18, they were chosen, because of their high tractive effort, simplicity of design, and general accessibility, as the standard goods engine for service with the British forces overseas, various detail modifications being made to suit the Continental stock they were to haul. Westinghouse pumps and piping were fitted, and many of the engines were fitted with steel fireboxes. In all, several hundreds were built. When returned to this country, they were distributed among various British railways, and some were sent to China and Australia. The majority, however, went back to the Great Central Railway, and, during the next 20 years, proved to be one of the most efficient types in this country from a traffic standpoint, and are also one of the cheapest and most easily maintained in the present freight locomotive stock of the London and North Eastern Railway. The parallel barrel and the straightforward Belpaire firebox make the boiler one of the simplest types to construct, and the outside cylinders leave ample space within the frame for access to the direct-driven Stephenson link motion.

During the present war, this type of engine was again chosen as the most suitable of the available stock for service with the British forces. The 92 engines that have been reconditioned and sent overseas all now have copper fireboxes and steam brakes. The general characteristics of the design are as follows:—cylinders, 21 in. in diameter, and 26 in. stroke; total evaporative heating surface, 1,503 sq. ft., of which 154 sq. ft. are in the firebox and 1,349 sq. ft. represent tube surface; superheater surface, 242 sq. ft.; and grate area, 26·24 sq. ft. The tractive effort is 31,326 lb.

THE INDUSTRIAL HISTORY OF RUSSIA: ERRATUM.—We regret that an error, reversing the sense of the passage in which it occurred, escaped correction in the above article, on page 425, *ante*. In the 14th line from the bottom of the first column on that page, the words "improvement or" should read "impediment to".

SCHOLARSHIPS AT DARTMOUTH.—The Admiralty has recently sent us particulars concerning the scheme of scholarships at the Royal Naval College, Dartmouth. In the first place, 10 scholarships in each term (30 per annum) are awarded to boys from grant aided secondary schools. Secondly, a number of scholarships up to 10 in each term (30 per annum) are awarded to boys from other schools. These boys must be equal or superior in ability to those from grant aided secondary schools. At the first scholarship examination, held in the summer, the full number of scholarships was awarded in both categories, namely, 20 altogether. Candidates must be between 13¼ and 13¾ years of age on the December 1, April 1 and August 1 immediately preceding the respective entries in January, May and December in each year. Further particulars are obtainable from the Secretary of the Admiralty (C.W. Branch), London, S.W.1.

MODERN TECHNIQUE IN TRACTOR PLOUGHING.

For some time past, there has been considerable controversy regarding the comparative advantages of two-, three-, and four-furrow tractor ploughing. As a result, the Hampshire War Agricultural Executive Committee decided to organise a public demonstration in which the various types of plough, drawn by the different standard models of Fordson tractor, could be seen at work under similar conditions. Accordingly, Mr. L. G. Troup, the Committee's executive officer, made arrangements with Messrs. R. A. Lister and Company, Limited, of Dursley, Gloucestershire, who make the Lister-Cockshutt ploughs, to plough a field at King's Worthy, near Winchester, which was placed at their disposal for the purpose by the executors of G. E. Grey. The demonstration took place on Friday last, November 28, and was highly successful in its main object of showing the increased output that can be obtained by proper attention to the loading of the machines. The accompanying illustrations, Figs. 1 and 2, show a three-furrow and a four-furrow plough, respectively, each drawn by a Fordson "Green Spot" tractor.

The tractors used were standard machines, drawn from those which the Hampshire Committee's machinery department operates on regular contract work. The demonstration on Friday followed a series of comparative trials with Fordson tractors fitted with spade lugs, and others with rubber tyres, both with and without water ballast, and drawing two-furrow, three-furrow and four-furrow ploughs. The stubble field on light-medium loam, at King's Worthy, had a maximum slope of about 1 in 10 in the direction of ploughing and was comparable with a good many others, up and down the country, on which a two-furrow plough is commonly regarded as providing a suitable load for a tractor of the Fordson class. In the demonstration, one of the tractors was pulling a four-furrow Cockshutt plough, cutting furrows 9½ in. by 6 in., while another was pulling a three-furrow plough and a three-ring press. The work was being done in middle gear, and it was clear that both tractors had an ample margin of power in hand; yet the output of work was nearly double the amount that most farmers would regard as satisfactory under similar conditions.

Dynamometer measurements showed that the land had a mean ploughing resistance of about 8½ lb. per square inch of furrow section. The average draught, up and down the slope, of the four-furrow plough with 27T bottoms, tail presses, single-arm coulters and skims, was rather over 2,000 lb. The three-ring press added about 400 lb. to the draught of the three-furrow plough. Both tractors were fitted with water-ballasted pneumatic tyres, carrying about 2 cwt. of water per rear wheel. This added weight would be expected to add about 200 lb. to the limiting adhesion of the drive wheels, but was hardly necessary in the prevailing conditions.

Another convincing demonstration dealt with the proper setting of the plough. A badly-set three-furrow plough did indifferent work and required a drawbar pull of nearly 2,500 lb. from its tractor. After a few simple adjustments had been made, the plough did first-class work, while the draught was little more than half the former figure. The errors of setting, which were clearly explained by Messrs. Lister's agricultural adviser, Mr. E. Rea, were all concerned with simple points which an inexperienced ploughman would be liable to overlook. The demonstration was watched with close interest by several hundred Hampshire farmers and is likely to lead to many discussions in the neighbourhood. It certainly showed that ploughing is still a skilled operation, and that the first essential is to set the plough correctly, in order to reduce friction and to enable it to work to the best advantage.

TRACTOR-PLOUGHING DEMONSTRATION.

Fig. 1. Fordson Tractor Drawing Three-Furrow Plough.

Fig. 2. Fordson Tractor and Four-Furrow Plough.

Control of Sulphur.—The Minister of Supply has issued the Control of Sulphur (No. 1) Order, 1941 (S.R. & O., 1941, No. 1798, price 1d.), which fixes maximum prices for sulphur ground from crude sulphur. The Order concerns all sales of 2 cwt. gross weight and upwards.

Welded Ships.—We have received from the Institute of Welding a copy of a bibliography, prepared by the librarian of the Institute, of books, pamphlets, press cuttings and abstracted periodicals relating to the use of welding in ship construction. The period covered is 1931-41. Many of the entries are accompanied by brief synopses of the articles or papers concerned, and, where a bibliography is appended, the fact is noted. Though there are very few German, French or Italian items, the majority of the references being to British and American publications, the bibliography is undoubtedly a valuable guide to the literature of the subject. Copies are obtainable from the Secretary, the Institute of Welding, 2, Buckingham Palace-gardens, Buckingham Palace-road, London, S.W.1., at the price of 3s. each.

The Late Mr. G. A. Mower.—We note with regret the death of Mr. George Augustus Mower, which occurred at his home in Collingham-gardens, London, S.W.5, on November 26. Mr. Mower, who was chairman of Messrs. Sturtevant Engineering Company, Limited, Igranic Electric Company, Limited, The Bifurcated and Tubular Rivet Company, Limited, and Crosby Valve and Engineering Company, Limited, was born in the United States in 1860. He studied at the Boston College of Technology and after graduating visited England, in 1883, on behalf of the Crosby Valve Company and the B.F. Sturtevant Company, both of Boston, U.S.A. In 1884, he took up permanent residence in this country and, in the following year, founded the Sturtevant Engineering Company, Limited, and, later, the Crosby Valve and Engineering Company, Limited. He also acquired a controlling interest in Messrs. The Bifurcated and Tubular Rivet Company, Limited, Aylesbury, which firm he reorganised. In 1898 he took up the agency of Messrs. The Cutler Hammer Company, of Milwaukee, and, in 1913, in order to manufacture and develop further their patented control gear in this country, founded the Igranic Electric Company, Limited. Although Mr. Mower retained the chairmanship of these companies until his death, ill-health prevented him from taking his former active part in their administration in recent years. He was elected a member of the Institution of Mechanical Engineers as long ago as 1884, and was a life member of the Institution.

Regional Fuel and Power Controllers.—The President of the Board of Trade has appointed Regional Fuel and Power Controllers, in the Civil Defence Regions, to co-ordinate the regional activities of the departments concerned with coal, gas, electricity and oil, and, in emergency conditions, to take charge of these interests under the Regional Commissioner. The day-to-day administration of these departments in the various regions, however, will continue as at present. Furthermore, these appointments will not affect the work or position of the Board of Trade representatives on the Production Executive's Regional Boards. The names of Regional Fuel and Power Controllers are as follows:—Scottish Region, Sir Nigel Campbell; Northern Region, Mr. Clive Cookson; North-Western Region, the Earl of Crawford; North-Eastern Region, Dr. H. S. Houldsworth; North Midland Region, Sir William Firth; Midland Region, Sir Bernard Docker, K.B.E., J.P.; Eastern Region, Mr. H. H. Holmes; Welsh Region, Mr. E. L. Hann; Southern Region, Colonel H. W. Woodall, C.I.E.; and London and South-Eastern Region, Colonel J. C. Dalton. The name of the Controller for the South-Western Region will be announced at a later date.

LABOUR NOTES.

THE claims of the Confederation of Shipbuilding and Engineering trades for a wage advance of 10*s.* a week on basic rates, for shipyard workers, was heard on Friday last week by the National Arbitration Tribunal. The proceedings were in private. The Shipbuilding Employers' Federation had refused to agree to the proposal on the ground that there had been no change in the circumstances since the Tribunal's award in January last of 3*s.* 6*d.* a week. The application of the Engineering Joint Trades Movement for a similar increase of 10*s.* a week on basic rates is to be heard by the Tribunal to-day (Friday). This was refused by the Engineering and Allied Employers' National Federation a week or two ago. The claim of the Amalgamated Engineering Union and the National Union of Foundrymen—which was also refused by the Engineering and Allied Employers' National Federation and is for an increase of 4*d.* an hour on basic rates—is to be heard on Monday. The Amalgamated Engineering Union are understood to have asked that their claim should be heard in public.

The Minister of Labour and National Service has amended the Conditions of Employment and National Arbitration Order to provide for the constitution of the National Arbitration Tribunal from a panel of not more than five appointed members, of whom two, in addition to the chairman, shall be selected by the Minister to sit for any hearing. The appointed members are Sir Gavin Turnbull Simonds, Sir John Forster, Sir William David Ross, Sir Francis Floud and Mr. Arnold Nixon Shimmin. Whenever present, Sir Gavin Simonds will be chairman of the Tribunal.

In the House of Commons on Thursday last week, Mr. Dunn, the Labour Member for Rother Valley, asked the Minister of Labour and National Service whether he was satisfied, in view of the man-power situation in the building and civil engineering industries, that the control over the disposition of labour was adequate to ensure the best and most economical use in the national interest.

Replying, Mr. Assheton said that the Ministry of Works and Buildings and the Ministry of Labour and National Service were at present actively engaged in strengthening the arrangements for the control of labour in these industries and it was hoped to make an Order very shortly under which (1) the transfer of employees of contractors from one contract to another would be made subject to the consent of a National Service Officer; (2) employers would be required to notify the National Service Officer of all terminations of employment; and (3) workers on leaving employment would be required to report at an employment exchange. These steps were designed, it was added, to ensure that labour in the building and civil engineering industries was moved only to essential work and utilised to the best advantage and with the utmost economy in relation to the national need.

In a statement on the development of old-age insurance and assistance under the American Social Security Act submitted to a Senate Committee by Mr. Altmeyer, the chairman of the Social Security Board, it is emphasised that any proposals for bettering the existing provision for the aged must take account of the probability that the proportion of the population aged 60 and upwards will double in the next 40 years and also of the wide variation in income levels and cost of living in different regions of the United States.

Mr. Bevin's appeal for increased war production during the next six months was described in a recent issue of the *Lancet* as "folly." "We can be ruthless with materials," the writer declared, "but not with the human tools that fashion them. . . . Admittedly excessive overtime for a long period has a devastating effect on the human reserve of strength both physical and mental. Over short spells of a month or two, or even three, as after Dunkirk, effort can be greatly intensified without collapse. But over six months . . . it would be folly to drive factory workers blindly without regard to rest and recreation."

A deputation from the British Medical Association presented to the Minister of Labour and National Service, last week, the report of a committee of the Association which states that illness and accidents could be very much reduced if every factory, large or small, arranged for the medical care of the employees during working hours. Medical supervision means, the report states, "a continuous supervision of the health of the individual worker in his industrial environment; the prevention, so far as possible, of physical and mental illness; a service for the initial treatment of injury; and an efficient medical liaison between the factory and outside medical services, such as the patient's own doctor, the hospital, the public health authorities, and the rehabilitation services."

The need is emphasised in the report for the closest co-operation between the industrial medical officer and the employee's own doctor. Large factories or factories with special risks, it is suggested, would find the appointment of a whole-time industrial medical officer more efficient and economical. Small firms could appoint a part-time medical officer, or neighbouring firms could combine to make a joint whole-time appointment. An adequate medical service, it is claimed, does not necessarily need an elaborate or expensive organisation and is within the reach of small firms. The committee recommends the setting up of an advisory body outside the factory, and perhaps sponsored by the Government, to help employers in making medical appointments and to assure the employees that the medical officer is not employed in the interest of the employer only.

According to the Chief Inspector of Factories, there were 24 per cent. more fatal accidents in 1940 than in 1939. Commenting upon that, the writer of the editorial notes in *Man and Metal*, the journal of the Iron and Steel Trades Confederation, says:—"That an increase would take place was to be expected with the increasing tempo of production and the entry of new and untrained labour into industry. It would, however, be a gross mistake to attribute this increase to those causes alone, and if it were possible to conduct a thorough examination and obtain a proper analysis of all the reasons which bring this about, it might well be found that the conditions arising from the war contributed very little to this state of affairs. The vital factor, in our view, is the importance, or otherwise, that is attached by the managements to the need for reducing the accident rate and the preventative measures taken to make it impossible for accidents to occur.

"Where you have a keen and efficient safety officer," the writer goes on to say, "the rate of accidents can decline even in war-time. This is shown in the case of a very large shipyard where the accident rate was reduced between 1937 and 1940 from 0·94 per cent. to 0·66 per cent. A shipyard to-day is as busy a place as any, and what can be done there can be done in any other undertaking."

Under an award of the Industrial Court, issued last week, labourers employed in war-time Admiralty establishments are to receive wage increases. At present labourers in these establishments are paid from 48*s.* to 74*s.* 6*d.* a week, according to the rates paid to similar employees in other industries in their districts. For the lowest paid, the basic rate will be 29*s.* and the bonus 30*s.* 6*d.*, making the minimum 59*s.* 6*d.* For employees getting over 59*s.* 6*d.* and not more than 60*s.* 6*d.*, the basic rate will be 30*s.*, raising the wage to 60*s.* 6*d.*; for those getting from 60*s.* 6*d.* to 63*s.* the basic rate will be 31*s.* 6*d.*, raising the wage to 62*s.*; and for those getting from 62*s.* to 63*s.* 6*d.*, the basic rate will be 33*s.*, raising the wage to 63*s.* 6*d.* Where the present rates exceed 63*s.* 6*d.*, there will be no change but the rates will be deemed to include the present bonus of 30*s.* 6*d.* In future, changes are to correspond to the rates of pay or bonus payable to labourers in the Royal Dockyards.

American officials are making a much more conservative estimate of the trend of unemployment during the coming year than they did, twelve months ago, at the inception of the large scale defence programme. Both the American Federation of Labour and the Congress of Industrial Organisations anticipate a reduction in unemployment of about 2,000,000 during the second year of the defence programme. The Work Projects Administration, however, estimates that the average increase in employment will range only between 2,000,000 and 2,500,000 and that the decrease in unemployment cannot be expected to exceed 1,500,000. The Work Projects Administration has come to the conclusion, therefore, that unemployment will average between 5,500,000 and 7,500,000 during the fiscal year ending June 30, 1942.

On Saturday last the Ministry of Labour and National Service called on all managements and employees engaged on war work to continue production at Christmas and the New Year, taking as a break either Christmas Day or New Year's Day. In the case of other establishments and services and, in particular, in retail shops, no departure from the customary arrangements was desired except to the extent necessary for meeting the requirements of those continuing at work.

A CENTURY OF TUNNELLING.*

By W. T. HALCROW, M.I.Mech.E.

(*Continued from page* 436.)

IN hard solid rock, lining is generally not required for the purpose of support, though occasional lengths may be met with where the rock is softer or friable and requires protection. The purpose of the tunnel may, however, render lining necessary or desirable. In some cases, a smooth surface is essential. In a tunnel through rock for the passage of water (Fig. 3, page 458,) a lining of concrete finished to a reasonably smooth surface reduces the frictional resistance to a notable degree and thus increases the discharge capacity of the tunnel, or alternatively, reduces the size of tunnel required for a given discharge. In tunnels where not only a smooth finish, but absolute watertightness, is essential, as in certain subway tunnels and in magazines, a satisfactory method is to make a separate inner lining and to allow any percolation through the walls of the tunnel to drain away through the space between the inner and outer linings. For rock tunnels requiring a smooth finish, a cement gun can be effectively and economically employed to render the sides and arch, if the overbreak is not great.

A roadway tunnel through the Alps was started as long ago as 1450, but was never completed. With the advent of the railway, tunnel communication between France and Italy became a matter of great importance. The longest tunnel which had hitherto been driven was the Box tunnel, near Bath, constructed in 1837-41, and having a length of 1·8 miles. A tunnel through the Alps presented a problem of far greater magnitude. The difficulties expected, and to a great extent realised, were: the exceptionally long headings, owing to the great length and depth of the tunnel, and the impossibility of providing intermediate shafts or adits; high temperature; and the difficulty in securing adequate ventilation. At the time the Alpine tunnels were commenced, the science of tunnelling had not advanced very far; hand drilling was still in vogue, electric light was not yet available, and the art of ventilation was in its infancy. It was in connection with the first Alpine tunnel that power drills were devised and used.

The first tunnel was the Mont Cenis, 8 miles in length, commenced in 1857. Power drills were started in 1861 and the tunnel was completed in 1870 and opened for traffic in the following year. During the first trial runs, great trouble was experienced owing to inadequate ventilation; heat, lack of air, and fumes from the locomotives led to the suffocation of more than one engine driver. Special smoke-consuming locomotives were then provided and the trouble was overcome. The St. Gothard tunnel, 9¼ miles long and 26 ft. wide by 2 ft. 6 in. in height, was commenced in 1872 and completed in 1880; an achievement which showed a considerable advance in the rate of progress, notwithstanding the greater difficulties encountered. These arose from water coming in under pressure through seams in the rock, and from disease due to the vitiated air caused by inadequate ventilation, rock dust, and the use of oil lamps and animal transport. Then followed the Arlberg tunnel, 6¼ miles in length, constructed in 1880-83; and later, the Simplon tunnel.

The Simplon tunnel was commenced in November, 1898, and opened for traffic in January, 1906. It was 12½ miles long and in its construction even greater difficulties were encountered than in the earlier Alpine tunnels; but, with the experience already gained and with improvements in tunnelling devices, a remarkable advance in the rate of progress was registered. The project comprised two parallel tunnels, one of which was to be driven to its full section of 250 sq. ft. and the other to a reduced section which was ultimately to be enlarged to the same area. The tunnel was in gneiss, mica schist, and limestone in which heavy discharges from springs occurred. At a point nearly 3 miles from the Italian side, a particularly heavy spring was met, which held up the work at the face for six months. Still later, when nearly 6 miles in, a hot spring at a temperature of 114 deg. F. was encountered, and it was found necessary to pump in cold water to reduce the temperature. In places, under the action of water, the mica schist disintegrated and necessitated heavy timbering. In the light of previous experience, great care was taken in connection with ventilation. Steam locomotives with their fires damped were used for haulage to a point within 2 km. of the working face, beyond which they were replaced by air-driven locomotives; cold-water sprays were used to reduce the temperature—a necessary precaution as the rock temperature reached a maximum of 133 deg. F. at the deepest part of the tunnel. Cross-connections to the parallel tunnel facilitated ventilation and also enabled the latter to be used for draining water from the springs.

* The 28th Thomas Hawksley Lecture, read before the Institution of Mechanical Engineers, London, S.W.1, on Friday, November 21, 1941. Abridged.

The Simplon tunnel took just over seven years to complete, a remarkably short period in view of the difficulties encountered. A rotary hydraulic drill was devised and used on this tunnel with great success, and an average rate of progress of 96 ft. per week was achieved. For the permanent ventilation, a forced-draught plant was installed at each end of the tunnel.

Of the Alpine tunnels subsequently constructed, mention may be made of the Loetschberg tunnel, 9 miles long. A heavy inrush of water flooded the tunnel and was ultimately found to derive from a river, 600 ft. above, in the bed of which a deep gravel-filled crevice was discovered, extending down to the tunnel level. The tunnel was then blocked by a bulkhead and from above this point the line was modified to make a detour round the place.

The Shandaken tunnel, New York State, forming part of the New York water-supply system, was driven during 1917-22. It was of horseshoe shape, 10 ft. 3 in. by 11 ft. 6 in., and 18 miles in length, through hard blue limestone and altered shales. A top heading and bench were used, and the drilling of the face was done with four Ingersoll drills on columns, and that of the bench with jackhammers. The average progress at each face was 91 ft. per week and the maximum, 153 ft.

The Lochaber (Ben Nevis) tunnel is the longest British tunnel. Its 15-mile length was subdivided for construction purposes into twelve stretches (the longest 8,210 ft.), by four shafts and seven adits. The tunnel was in hard rock throughout and was almost completely dry. Holes 8 ft. to 10 ft. in length were drilled, and the maximum weekly progress at any face was 91 ft. The loading of the spoil into wagons was, for the most part, done by hand. An interesting feature of this tunnel was its inlet into Loch Treig, at a point 104 ft. below water level (Fig. 4, on this page), where the rock consisted of sound mica schist. The tunnel was driven to within 85 ft. of the lake; the heading was then kept 20 ft. in advance, and taken to within 16 ft. of the water. The tunnel was next widened out to its full section at this point, the sides, however, being left at a distance of 20 ft. from the water. A strong concrete bulkhead was built across the tunnel just downstream of the inlet sluice shaft. In the thin rock walls left against the lake (Fig. 5, on this page), 135 holes were drilled to within 2 ft. of the water. These holes were loaded with a charge of 3,435 lb. of gelignite, and fired. Part of the debris fell into a sump specially prepared for that purpose and the remainder was cleared with a dragline scraper. The inlet gate was then lowered and the bulkhead removed.

A somewhat similar lake junction was carried out in 1940 at the Snow Lake tunnel in America. This tunnel, 5 ft. by 7 ft., and 2,350 ft. long, had its inlet in Snow Lake, 165 ft. below water level. The methods adopted were much the same as at Lochaber; but, after careful testing, a thinner rock wall was left to the final blast, which was effected with thirty-two holes 4½ ft. to 5 ft. long, the charge being 220 lb. A rather larger sump, in proportion to the material in the wall, was made to accommodate the debris, and little or no subsequent clearing was found necessary.

(*b*) *Tunnels in Soft Soil, and Soil which is not Self-Supporting.*—This class covers tunnels in material which is not self-supporting; it excludes those constructed with the aid of a shield. Timbering is required to prevent the roof or sides from caving in during construction, and it is ultimately replaced by a permanent lining. Though the material is in itself easier to excavate than rock, the difficulties are otherwise much enhanced. In addition to the removal of spoil from the tunnel, materials for lining and timbering have to be brought in, thus introducing two-way loaded traffic. Further, the timbering takes time to erect and restricts the working space. In extreme cases, as in mud or running sand, the face has also to be supported. In the Hudson River tunnel, an attempt was made to harden the mud at the face by heat. In other cases, chemical consolidation of the ground and grouting have been adopted.

The Joosten process of chemical consolidation of loose sandy soil, which has been successfully applied to tunnel, foundation, and other work, may be briefly described. Pipes are driven into the tunnel face with a pneumatic hammer, and at regular stages of the driving a measured quantity of a solution of sodium silicate is injected under pressure through the pipe. The pipe is then withdrawn by similar stages, at each of which a measured quantity of a solution of calcium chloride is injected. The two chemicals combine to form a cementing material which binds the particles of sand together to form a solid impervious mass. The excavation is then readily carried out through this material until the untreated soil is reached, when the process is repeated. The grouting process consists of driving pipes into the tunnel face and injecting cement grout through them under pressure.

The main feature of this type of tunnel is the timbering required to support the sides and roof until the permanent lining is built; where, owing to the nature of the soil, the timbering is heavy, it forms the operation which largely determines the rate of progress that can be maintained. In these days, if the ground is so bad as to necessitate very heavy timbering, a shield would generally be used. There are two main systems of timbering, which differ so greatly that I may refer briefly to them.

The English system comprises a series of longitudinal bars supporting poling boards along the roof and sides,

A CENTURY OF TUNNELLING.

FIG. 3. BEN NEVIS TUNNEL.

Fig. 4.

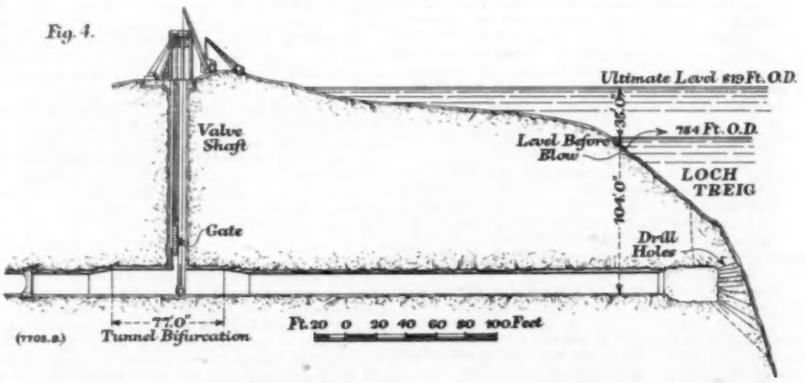


FIG. 5. BEN NEVIS TUNNEL: ROCK FACE DRILLED FOR BLASTING.

A CENTURY OF TUNNELLING.

Fig. 6.

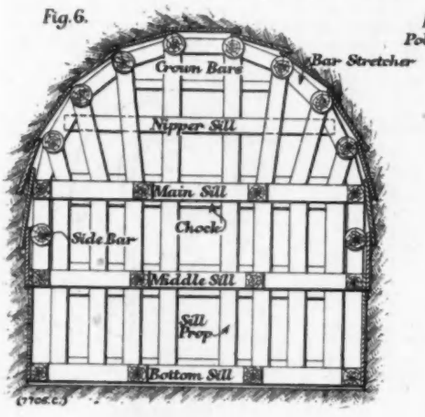


Fig. 7.

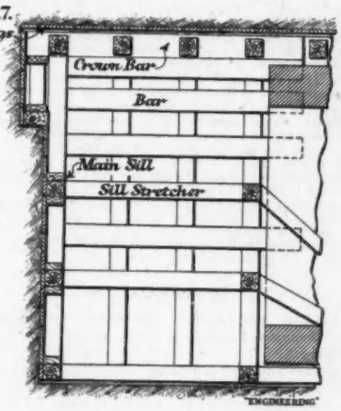


Fig. 8.

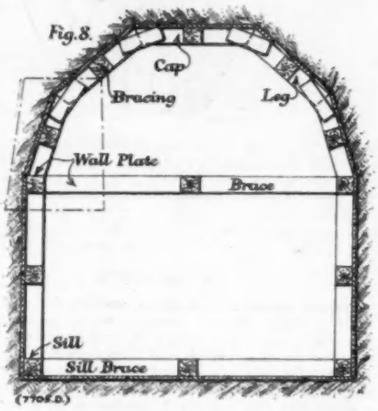


Fig. 9.

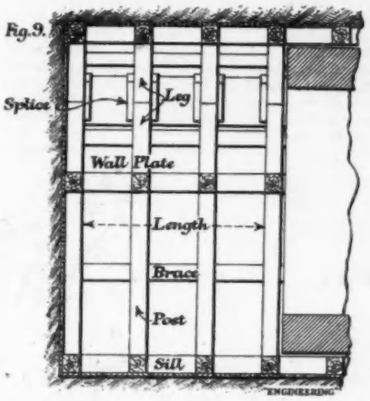


FIG. 10. GREATHEAD SHIELD.

and separated by cross-pieces or stretchers. These bars are in turn supported by props resting on sills, the number of sills being determined by the height of the tunnel. The arrangement is shown in Figs. 6 and 7, on this page. The usual procedure is to start with a top heading and get in the two top or crown bars first. The heading is then widened on each side to get in further bars. These bars are propped on an intermediate or "nipper" sill. The top section being completed, excavation then proceeds downwards, and the support is transferred to the main sill, and thence to the middle and bottom sills. Soft ground necessitates a heavy mass of timbering which leaves little working space. The bars are now often replaced by steel beams which take less room.

The American system comprises the support of the roof by a series of arches at right-angles to the axis of the tunnel. These rest on wall plates, propped on intermediate and bottom sills. The wall plate and bottom sills on each side of the tunnel are strutted by a brace. The arrangement is shown in Figs. 8 and 9, on this page. Any considerable length of tunnel under timber is to be avoided, not only for reasons of safety, but also to reduce the amount of timbering required. The lining is therefore put in as rapidly as possible. Notwithstanding this, the consumption of timber is very large. Drinker gives the quantity of timber required per 100 cub. ft. of excavation as from an average of 7 cub. ft. for firm ground to an average of 53 cub. ft. in running sand.

A recent development is the use of pressed steel liner sheets, supported by steel ribs and struts, in place of timbering. The liner is light and easily erected and the system saves excavation and gives more working room. If compressed air is being used in water-bearing soil, steel sheets, as they involve fewer joints, lead to less air leakage. The steel liner is generally left in when the concrete lining is placed; and in work where any settlement would be serious (as under streets) the space, if any, behind the liner is grouted. In excavating tunnels in soft materials, the work is generally done by hand, the working space being too restricted for the use of mechanical excavators. The ordinary hand tools, such as picks, spades, and, in clay, cutting knives, are often supplemented by pneumatic picks and spades, and power knives.

This class of tunnel is most generally lined with brick or concrete, deposited *in situ*. Various methods are used for transporting the concrete from the mixer to the work, a convenient device being a conveyor belt. An interesting innovation which has recently been successfully employed consists of pumping the concrete through a steel pipe line from the mixing station, outside or farther back in the tunnel, to the work. In long tunnels, steel shuttering is frequently used and is sometimes fixed on travelling carriages. It is hardly necessary to describe any particular tunnels of this class, which includes the greater part of many railway tunnels, other than those in rock, which have been driven through non-water-bearing ground and a good many where water has been encountered in considerable quantity. I may, however, mention the tunnel through the Apennines, constructed by the Italian State Railways in 1923-28, as an interesting example of a timbered tunnel. It is 11¼ miles in length, and horseshoe-shaped, with a width of 20 ft. The soil was mostly disintegrated rock, necessitating timbering. The average rate of progress attained was 9 ft. drive per day on the south side, or, say, 50 ft. a week, and 7½ ft., or, say, 40 ft. a week on the north side, where difficulties were met with from water and from inflammable gas.

(c) *Tunnels Constructed with the Use of Shields.*—This method is adapted to tunnelling in soft and treacherous ground. The shield consists essentially of a short box or tube, covering the periphery of the tunnel and suitably stiffened against collapse from external pressure. Under the cover of this, excavation is carried on at the face. As the excavation proceeds, the shield is driven forward by jacks placed round its circumference and thrusting against the completed lining of the tunnel, which follows close behind the shield. The back end of the shield is extended by a short length, free of any internal structure, and within this extension the lining is built. As the shield moves forward, a space is left between the lining and the excavated side of the tunnel, which is immediately filled in by grouting with lime or cement. The lining is generally made of cast-iron segments, bolted together to form a ring. The advantage of this method is that the lining can be built up without the use of centring or shuttering, as would be required with a concrete or brickwork lining; and, as each ring is completed, it is then ready to take the thrust of the shield jacks, without the delay which would arise if one had to wait for the concrete or mortar to set. Cast iron is not an essential accompaniment to shield tunnelling, but its adoption is frequently more convenient and leads to expedition of the work. Other materials are sometimes used.

In the London tube system, the tunnels are generally carried out with the use of a shield and with cast-iron lining. The geological formation of the London area is of London clay overlaid by claygate (a mixture of clay and sand), and river terrace gravels and sands, overlying in turn the Woolwich and Reading beds of water-bearing gravels and sands. The thickness of the London clay being variable, the tubes pass in various places through the upper or lower gravel and sand beds.

While the use of the shield is probably the greatest advance in the art of tunnelling in modern times, it should not be supposed that it is the best method for all conditions of soft material and that it has rendered other methods obsolete. This is by no means so; for instance, the shield is rarely used for short drives. On the other hand, it is of great service when tunnelling through soft and treacherous ground, and it is particularly valuable for subaqueous work. In semi-fluid

soil, such as the mud of the Hudson River, the shield has revolutionised tunnelling, and many schemes have been carried out which would have been impracticable without it.

The two main advantages of shields are :—First, the safety it affords in bad ground ; and second, the fact that it reduces or obviates the use of timbering. Heavy timbering is costly and leads to slow progress. On the other hand, a shield is an expensive item of plant. If the tunnel is of a standard size, as in the case of the London tubes, the shield can be taken from job to job (with the exception of the skin, which must be left), and the cost will be distributed ; but if it is of large or special size, then it becomes so heavy a capital charge on the work that it might be prohibitive on a short tunnel. Where a shield is not essential from the point of view of safety, its use depends, therefore, on economical considerations. Special cases arise, however, where the shield is unnecessary either on grounds of safety or economy, but where a greater rate of progress may be attained by its use ; if speed is the primary consideration, it would then probably be employed.

Though the shield in its present form is a fairly modern device, its inception dates back earlier than the beginning of the century under review. It was due to M. I. Brunel, who patented the idea in 1818 and used it in the construction of the first tunnel under the River Thames. In broad principle, however, Brunel's shield and the modern shield differ very little. The shield marked an outstanding advance in tunnel practice, but it was perhaps somewhat ahead of the times, as it was not until 1869 that it was again used, on two tunnels simultaneously, one under the Thames and the other in New York ; but in the interim the idea was not lost sight of, and a number of patents in connection with it were taken out. The first shield, designed by Brunel and applied by him to the construction of the Thames tunnel, differed from the later shields in one essential feature, namely, that it was made up of a number of separate units, each of which could be moved forward independently of the others. The next shield, that designed by Greathead for the Tower Subway tunnel, a much smaller tunnel, was the prototype of the modern shield. It consisted of a single unit moved forward as a whole, a principle which was adopted universally in all subsequent shields, even of the largest size. The modern shield is, in its essentials, the same as Greathead's first shield. Fig. 10, on page 459, shows a shield of this type.

The essential components of a shield are :—(1) the skin or tube, which is sharpened at the front to form a cutting edge ; (2) the internal structure which stiffens the tube ; and (3) the jacks for pushing it forwards. These are invariably hydraulic and are arranged circumferentially round the rim and parallel to the tunnel axis, and they thrust against the finished lining. When used in compact ground, the front of the shield may be open ; but in softer ground a diaphragm plate is used, through which a single door in small shields, or multiple doors or sliding shutters in the large sizes, give access to the working face.

In soft soil, the face of the excavation must be supported with poling boards, and the timbering may also have to be carried round the perimeter of the tunnel in front of the shield. The poling boards are held by horizontal walings, retained by vertical posts or soldiers which are strutted back through the openings of the diaphragm against the completed lining. Alternatively, the timbering is supported by face jacks on the front of the shield, a device now generally adopted for shields for use in soft ground ; it was first used on the Waterloo and City Railway in 1895. The shield is the same, whether it is being used in combination with compressed air or not. Airlocks in the shield itself have been tried, with the purpose of maintaining a higher air pressure at the working face than in the remainder of the tunnel. These systems of differential pressures have not been found to be of much benefit, and they are cumbersome. They have now gone out of use. To meet the contingency of a sudden inflow of water at the working face, shields are sometimes provided with a water trap and hanging diaphragm, through which suitable hollow cylindrical struts are passed for independent support of the working face when the shield is being moved forward. These struts are fitted at one end with a screw adjustment ; at the holes in the diaphragm and water trap, reasonable watertightness is secured by the provision of leather sleeves through which the struts pass.

(To be continued.)

MOTOR FUEL FOR HIRE-SERVICE CARS.—The Secretary for Petroleum has announced that he has made an Order, entitled the Motor Fuel (Hire Service) Order, 1941 (S.R. & O. No. 1745, price 1*d.*), which is designed to check and control the consumption of petrol through the hired-car system for purposes not connected with the war effort or essential business. The Order came into force on November 24.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case ; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

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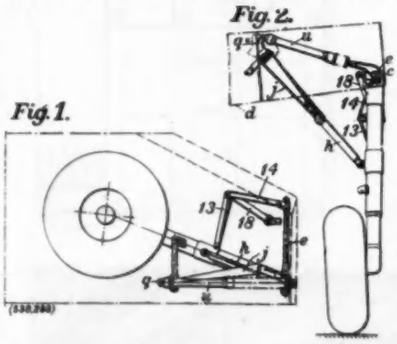
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

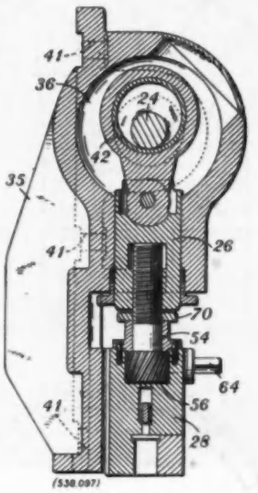
538,298. Retractable Undercarriage. The Fairey Aviation Company, Limited, of Hayes, and F. J. Costigan, of Colnbrook. (5 *Figs.*) April 30, 1940.—The invention is a retracting mechanism for swinging a wheel upwards and slightly rearwards so that in its stowed position it lies between the spars of the aircraft wing. The landing wheel is carried by an oleo leg pivoted at *c* on the aircraft wing. The pivot rod *c* is itself pivoted about a fore and aft axis, and to one side of the oleo leg is pinned a knuckle-joint and strut *h*, *j*. The axis of the knuckle joint is slightly inclined to the axes of the two limbs of the strut, so that when folded the limbs *h*, *j* are not superposed on one another, and can be locked in the extended position by a spring bolt. Pivoted on the wing *d* about the axis of the upper limb *j* of the strut is a curved extension *q* with opposite shoulders to abut against corresponding



shoulders at the top of the limb *j*, a small amount of pivotal movement between the extension and the limb being possible. To the free end of this extension *q* is pivoted the plunger of a hydraulic jack *u*, the cylinder of which is pivoted to a arm fast on the rod *e*. A small tail-piece on the extension *q* is connected by a link to the spring bolt which locks the knuckle joint. To the rear of the oleo leg is pivoted the lower end of a two-part bracing strut 13, 14, the upper end of which is pivoted to an arm on the rod *e*. A link 18 connects the joint of the bracing strut to the wing, so that, as the jack expands and collapses the oleo leg, the joint of the strut 13, 14 is broken downwards and the strut is flexed. This flexing causes the oleo leg to move back about its transverse axis *c* as it is moved upwards. Provision is made for locking the oleo leg in the retracted position. (*Accepted July* 28, 1941.)

MACHINE TOOLS AND MACHINE-SHOP EQUIPMENT.

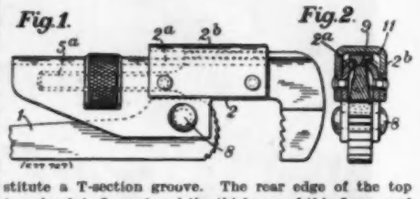
538,097. Power Press. C. W. Engineering Company, Limited, of Stoke-on-Trent, and F. A. Hancox, of Walsall. (11 *Figs.*) January 18, 1940.—The invention is a power press consisting of a main frame and a detachable unitary ram structure. The former can be fabricated with two vertical side plates and a horizontal table. The unitary structure carries the driving shaft 24 and a two-part ram 26, 28, and consists of a frame detachable from the main frame. This detachable frame has a back plate, two side plates and a chamber 36 at the top, and is open below at the front. The back plate has two rearward vertical cheeks 35 which lie against the side plates of the main frame. This detachable frame can be secured to the main frame by bolts or studs at 41. The driving shaft 24 is journalled in the chamber 36 and carries in the latter an eccentric 42 which operates the ram. The upper part 26 of the ram is connected to the lower part by an adjustable connection and constitutes a cross-head which is guided in the detachable frame below the chamber 36. The crankshaft and eccentric are thus accommodated in a part of the detachable frame constituting an oil-tight chamber for a bath of lubricant. The adjustable connection between the ram parts consists of a stud 54 screwed into the bottom of the cross-head 26, and with its head 56 rotatable in a socket in the lower part 28. This stud is rotated by a worm wheel formed by the head 56 and a worm on a spindle which projects from the ram and has a squared end 64. A



locknut 70 screwed on the stud 54 locks the latter in the lower end of the part 26 of the ram. The lower part 28 of the ram slides in V guides in the detachable frame. The press unit is small and compact and can be mass produced. The ram guides give improved alignment and the entire unit is easy to assemble and comprises no split bearings. (*Accepted July* 21st, 1941.)

MISCELLANEOUS.

537,767. Wrench. G. A. Steele, of Chiswick. (5 *Figs.*) April 30, 1940.—The invention is a wrench construction which minimises the tendency of the top jaw shank to bend in use. The wrench is of simple construction and consists of a lever 1, a U-section yoke 2 pivoted on the lever, a bottom jaw on the lever, a top jaw formed with a shank and a milled nut fitting loosely in a slot cut in the yoke 2 and threaded on an extension 5*a* of the shank. The yoke is fabricated, having a main part 2*a* and a guide piece 2*b*. The main part 2*a* consists of a piece of sheet metal bent to form a U the cheeks of which embrace the lever 1. In the bend of the U is cut a parallel-sided slot 9 which extends from the upper edge of the main part to a point below the level of the pivot 8. The guide piece 2*b* is also of sheet metal bent into a U-shape, and extends for substantially the length of the slot 9. It is riveted to the cheeks of the main part 2*a* in such a way that a small clearance is left between the bend in the part 2*a* and the corresponding inner surface on the guide piece 2*b*, and this clearance constitutes a transverse slot 11 which, with the slot 9, together con-



stitute a T-section groove. The rear edge of the top jaw shank is flanged and the thickness of this flange and of the adjacent web part are chosen so that the T-section so formed is an easy fit in the composite T-section groove 9, 11. The wrench illustrated is a pipe wrench, and for rotating a pipe, the jaws are adjusted to the required distance apart to permit the pipe to be slipped freely between them. The lever 1 is then swung to close the jaws firmly on the pipe. Continued movement of the lever rotates the pipe. It should be noted that the knurled adjusting nut is at a lower level than the pivot 8, so that the force closing the top jaw on to the pipe merely produces a tension in the shank extension 5*a* and does not tend to bend it as happens with the usual constructions of wrench. Furthermore, the shank is supported over its whole length against any tendency it may have to move away from the pipe by the engagement of the rear surface of the flange with the rear wall of the T-slot. An important advantage of the construction is that the thread 5*a* is fully protected against damage, since the bolt is virtually enclosed in the yoke 2 and cannot come into contact with other parts of the wrench. (*Accepted July* 4, 1941.)